COMBUSTION

Vol. 4, No. 8 FEBRUARY, 1933 25c a copy

300 ton per hr. coal unloaders, Dagenham Plant, Ford Motor Company, Ltd., England

STRESSES ON BOILER TUBES SUBJECTED TO HIGH RATES OF HEAT ABSORPTION

By Wm. L. DeBaufre

MODERN RESULTS FROM AN OLD PLANT

By R. D. Myers

Other Articles in This Issue By

JOSEPH KEENAN • CARL STRIPE • GEORGE RAMSEY • JAMES CUNNINGHAM

COMBUSTION

VOLUME FOUR • NUMBER EIGHT

CONTENTS FOR FEBRUARY 1933

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

H. STUART ACHESON
General Representative

CHARLES McDONOUGH
Editor

F. H. ROSENCRANTS
Associate Editor

COMBUSTION is published monthly by In-Ce-Co Publishing Corporation, a subsidiary of International Combustion Engineering Corporation, 200 Madison Avenue, New York. London office, Aldwych House, Aldwych, W.C.2. W. R. Wood, President; George H. Hansel, Secretary; W. I. Branigan, Treasurer.

SUBSCRIPTIONS, including postage, United States, $2.00, Great Britain, $2.50 a Year. Canada $3.00 (includes Canadian tax). Other countries, $3.00. Single copies: 25 cents.

Commentary by Joseph H. Keenan

The International Calorie

In the summer of 1929 there gathered in London a group of experts in steam research whose purpose was to reduce the discrepancies between steam tables originating in various parts of the world. Since four nations were represented it was agreed beforehand that the contributions of the various delegates would all be reduced ultimately to a common language. It was easy to agree on English, because Germans, Czechs and Americans could use it moderately well as a medium of expression. The problem of an acceptable technical language was less easily solved. The metric system was adopted for pressures, temperatures and specific volumes because it was more widely used in scientific work than the English system. But within the metric system there were as many different kinds of calories as there are B.t.u.'s in the English system. Each delegate carried his own particular brand of calorie in his brief case and was prepared to exhibit it and to extol its virtues on the slightest provocation. There were 15 deg. calories, 20 deg. calories and mean calories, each in an assortment of sizes.

"And the Lord said............let us go down, and there confound their language that they may not understand one another's speech.

"So the Lord scattered them abroad from thence upon the face of all the earth: and they left off to build the city."

Perhaps some recollection of the story of Babel brought home to the delegates the need for compromise and agreement. The American delegates proposed that all energy values be expressed in kilowatt-seconds; but the calorie was too dear to many hearts. It was Dr. Jakob of the Reichsanstalt who proposed the happy compromise. Kipling tells how a coat of paint and an inch and a half less tail made the canteen sergeant's dog a thoroughbred. Jakob's operation on the electrical unit made it pass for a calorie. Specifically, he proposed a new unit to be known as the "international calorie" and to be defined as 1/860th of an international watt-hour. This definition includes an approximation to the older calories, but it excludes the old uncertainty as to magnitude by referring only to the precisely known international electrical units. It does not even mention "the heat required to raise one gram of water one degree".

The international calorie was adopted for the purposes of the Conference, and was submitted through the secretariat to various national standardizing bodies. The replies from England objected to the general adoption of the new unit because heat was heat before anybody knew that it was just another form of energy; and in deference to history it was proper to define the heat unit or calorie only in terms of an amount of heat.

Later correspondence from England stressed the proposals of the British Association in 1895 which included a double definition of the calorie, consisting of, first, the amount of heat required to raise the temperature of 1 gram of water one degree centigrade at a mean temperature of 10 degrees, and, second, 4.2 watt-seconds. This was reduced to a single definition exactly paralleling Jakob's by a further stipulation that if further experiment showed the two definitions to be incompatible the second one, 4.2 watt-seconds, should stand. Thus, the London Conference could claim benefit of history from the records of the British Association.

The international calorie was not greeted everywhere with frowns of disapproval. Dr. Mueller of the Bureau of Standards celebrated its arrival by throwing a famous physics experiment out the window: "The recommendation of the London Conference means that the mechanical equivalent of heat is no more. The Steam Table Conference is to be congratulated that one of its major problems, the mechanical equivalent of heat, has been disposed of with a degree of finality that was doubtless not anticipated when its program was formulated."*

The international calorie is slowly displacing the old calories. Many recent researches in thermodynamics and at least one steam table has been published in terms of it. There is little doubt now that the international calorie will shortly be the only generally accepted calorie in the metric system. A corresponding acceptance of the kilowatt-second in place of the B.t.u. in the English system would be equally advantageous. Then both English and metric systems would have heat units of familiar size defined in terms of precisely known quantities.

Joseph H. Keenan

Stevens Institute of Technology

* I have condensed this statement.

EDITORIAL

The Tax Problem —A Challenge to Engineers

IN THIS issue, COMBUSTION momentarily steps out of its role as a technical journal to publish an article and an editorial on the subject of taxes. The article, which begins on the opposite page, sets forth, with commendable force and clarity, facts which reveal the seriousness of the tax burden; it also proposes a basic classification of taxes as an essential preliminary to intelligent revision of our tax structure.

This editorial seeks to enlist the interest of engineers in a practical program to effect tax reduction.

We have all been hearing, reading and talking a lot about taxes. Some of us are aware of the critical problem they constitute. Most of us, however, are unaware of the extent to which taxes affect us as individuals. In saying this, we include property owners and those who pay income taxes as well as those who pay relatively little in direct taxes. The point is that no large number in any tax-paying group realizes the extent to which taxes penalize employment, affect the prices of everything we buy, limit our earnings and handicap us in innumerable ways. If the sum total of taxes which we as individuals pay directly and indirectly each year was known to us we would no longer be content merely to discuss and perhaps complain—we would act.

As a starting point in a program of action which we as engineers are exceptionally qualified to undertake, let us consider a few facts. First let us realize more definitely than we do that taxes profoundly affect the economics of engineering. Every device or piece of equipment we design and every engineering project we undertake must reflect in capital cost and fixed charges the expense of taxes.

Next, in order to get a clearer picture of the part taxation plays in our national economy, let us review some recent statistics. According to figures of the Industrial Conference Board, income from taxes, federal, state and local in 1929 amounted to $9,759,000,000. The cost of all government for the same year was $13,048,000,000, the deficit being made up by borrowings which will have to be paid with interest. In 1930, taxes increased to $10,266,000,000, and while no figures are available, it is probable that the deficit was as great or greater than in 1929. Our national income in 1930 was approximately $71,000,000,000. In 1931, national income dropped to $52,000,000,000 while taxes dropped only to $9,519,000,000. Government deficits continued to increase. National income for 1932 has been estimated at figures ranging from $37,500,000,000 to $45,000,000,000. While the total of taxes may have dropped, the rate of taxation tended to increase and at present governmental agencies are seeking in every way to find new sources of tax and to increase existing sources as much as they will bear.

The ratio of tax plus accumulating debt to national income reflects a condition that is intolerable, that is retarding prosperity and that is menacing our economic stability.

Perhaps the most glaring example of governmental lack of concern for the taxpayer's money is that of veteran's legislation. In 1932, compensation on account of the World War totalled approximately $700,000,000. Our casualties in the World War totalled 344,000 men. In the same year France, with 5,623,000 casualties, paid in pensions and veteran allowances on account of the World War the sum of $287,000,000. In other words, we paid 40 times as much per casualty as France. With all proper recognition to veterans and our obligations to the dependents of those who gave their lives for their country, there is a disproportion here which cannot be countenanced. It is due in large measure to governmental generosity, inspired by a powerful vote-controlling lobby, in behalf of veterans who neither lost their lives nor were disabled in action.

Well what are we going to do about it? In every great emergency, it has been found that the greatest instrumentality for effective action is mobilization,—mobilization of thought and opinion to achieve definite objectives. This mobilization can be accomplished most readily through existing organizations. It matters little where the work begins or who starts it. If it is fundamentally sound and energetically pursued, it will gain recognition and be taken up by other groups until it assumes national proportions.

COMBUSTION suggests that the engineering profession regard the tax problem as one that is peculiarly suited to the logical thought processes characteristic of the engineering mind, as one that will readily lend itself to the step-by-step method of solution which engineers are trained to use, and finally as a national problem that perhaps more than any other, demands the attention of every citizen concerned with his country's welfare.

The engineering profession, in its various branches, is well organized. The officers of its major societies could initiate no more constructive and appropriate undertaking than to ask that their societies in all their national, regional and local meetings give the tax problem a place on their programs. This step will serve to stimulate interest and educate society memberships to an appreciation of the problem which individual members in turn can communicate to other local groups, trade, professional and fraternal. Such a program initiated by the national engineering societies, in cooperation with such groups as the National Economy League and the American Taxpayers League, Inc., would contribute greatly to interest in and aggressive action on the tax problem by influential groups in all sections of the country. Its effects would permeate all ranks of our citizenry and would establish a mandate that would compel action by public officials.

The tax burden today stands as a challenge to every element interested in good government and the restoration of national prosperity. By heeding this challenge engineers can render an exemplary service to the nation and to all branches of the engineering profession.

Our reasons for publishing this article are given in the editorial on the opposite page. The author, as the head of one of our large railroad systems, speaks with the authority that comes from long experience with taxation and its social and economic effects. He presents a clear and thought-provoking picture of the tax situation as it affects business generally and the individual tax-payer.

THE TAX BURDEN*

An Obstacle to Recovery

By L. A. DOWNS

President, Illinois Central System

I THINK it is correct to say that among railway men today will be found a very earnest desire to help those who are engaged in other kinds of business, and among business men will be found an equally earnest desire to help the railroads to find solutions to their problems. We have been through a great depression, but we are now on the road to recovery. We are going forward on it all the time, and each step we take brings us that much nearer the goal we all want to reach. *The greatest obstacle of all, along the road to recovery, is excessive taxation.*† I am sure I will be pardoned if I illustrate this point by turning to my own business, which is that of railroading.

The railroads of this country pay approximately one million dollars a day in taxes. It took the net revenue of more than 75,000 miles of railroad for the whole of 1931 to pay the 1931 taxes of the railroads of the country. In the first six months of 1932, the railroads worked 104 days for the tax collectors and only 79 days for their owners. There are literally hundreds of counties, school districts and other taxing units throughout the United States where the railroads pay more than one-half of all the taxes that are collected by those units.

It is not because of the effect of taxes upon the railroads alone, however, that I invite attention to this obstacle on the road to recovery. Taxation lays its heavy hand upon every one of us. It reaches into every worker's pay envelope. It takes something out of every landlord's rent check. It adds to the cost of our raw materials and our finished products and to the cost of transporting them. It makes our letters cost more, our gasoline cost more, our food and fuel and clothing cost more. It intrudes, directly or indirectly, into every business transaction. *It makes every one of us work one day out of every five, not for ourselves or for our families or for the business in which we are engaged, but for our various governments.*

Taxation is not a new problem, although it has grown and is still growing in size and importance. We have devoted much time and effort to it in the past. In the past, however, our primary emphasis has been upon eliminating inequalities of taxation. Our attitude seemed to be that, so long as the burden of taxation was distributed equitably among us, we did not care very much how heavy the burden. There are still many glaring inequalities of taxation that need to be straightened out, but we also require an understanding of our mutual interest in the reduction of all taxes.

One thing we need very much to realize, of course, is that the burden of government is something which we have put upon ourselves. No longer are taxes exacted from us by some authority higher than ourselves. For approximately a century and a half, we have been governing ourselves and taxing ourselves, and the load of governmental expense and taxation that has grown so burdensome is of our own making. *Taxes are high because we have let them come to be high, and they are going to be reduced in direct ratio to the effort which we are willing to put into having them reduced.*

Many Expenses Legitimate

We also must realize that many of the governmental expenses which cause taxation are for legitimate and necessary projects. We cannot very well get along without an army and a navy for national defense. We need an adequate police force and a fully equipped and fully manned fire department for local protection of our homes, lives and property. Public education has come to be accepted as a natural and proper function of government. All these and many other things are more or less properly regarded as essential, and payment for them cannot be avoided, even if it does add —in some cases greatly—to our burden of taxes.

I do not mean to say that we should condone waste and extravagance in these necessary expenditures. We all have had to economize greatly in our respective fields of endeavor, and I think we are entirely within

* Reprinted from January, 1933, issue, EXECUTIVES SERVICE BULLETIN, published by Metropolitan Life Insurance Co.
† Italics throughout this article are ours.

our rights in demanding that the spenders of our tax money exercise comparable economy in expenditures for even the necessities of government. Again I turn to my own business for illustration. Our economizing has not been a case of what we have wanted to do; it has been a case of what we have had to do. We have had to reduce purchases, consolidate and eliminate departments and divisions, take off trains, close stations and do a thousand and one other unpleasant things to reduce our outgo and to bring it within reasonable distance of our income. Necessity is a hard taskmaster, and we all have felt its lash in the last three years. If we have overlooked anything, it is in failing to demand as sternly as we ought that the spenders of our tax money go as far as we have had to go in economizing, even in necessary expenditures.

The path to tax reduction, of course, is through reduction of governmental expenditures. As a step toward tax reduction, I suggest that governmental expenditures be grouped into these three classes.

First, I would list the expenditures that are absolutely essential. In this class fall the expenses of the primary functions of government—the cost of operating the executive, legislative and judicial branches; the protection of life and property, national defense and activities of similar nature which are of direct or indirect benefit to every member of our population.

Second, I would list the expenditures that are nonessential but at least relatively harmless. In this class fall those governmental activities which have developed in more or less recent years at the demand of organized minorities with the tacit consent or agreement of the public generally.

Third, I would list those activities of government and those expenditures of tax money which, under the guise of helping one portion of our population, serve principally to hurt others and to increase the burden upon all the taxpayers.

As I have said before, I believe we should demand the exercise of utmost economy even in the most necessary of governmental functions. True economy does not mean, necessarily, going without, but it does mean the avoidance of waste, the elimination of every kind of extravagance and the receipt of a dollar of honest value for every dollar spent. These principles should be our guide in all expenditures of tax money.

As to the second classification, I think the time has come to revise our thinking as to what constitutes the proper functions of government. In the past, we seem to have been guided largely by the principle that we should have the government do for us everything that it can do approximately as well as private enterprise can do. *I propose that we should have the government do nothing for us which private enterprise possibly can do.*

As to the third classification — those expenditures which, in the guise of helping a portion of our population, hurt other portions and lay a heavy hand upon all taxpayers — it would be impossible for me to express myself as strongly as I feel. Every citizen who is engaged in a lawful and honorable enterprise has a right to expect and demand that he be given an opportunity to conduct it with a minimum of governmental interference.

If I speak with some emphasis upon this phase of the subject, it is because, as a railroad man, I come up against this very thing. The railroads have suffered as no other industry has suffered from the misdirected efforts of government in the field of regulation and interference with the operation of natural laws. I take no narrow view of other forms of transportation. I think there is a place in a rounded national system of transportation for water carriers, road carriers and air carriers, as well as rail carriers. However, I do feel very strongly that, in order to find their respective places, it is necessary that all forms of transportation be required to stand on their own feet, that they be regulated alike, and that subsidies in every form be withdrawn from their support.

Against favoritism in government, the railroads have resolutely set themselves and pledged their earnest efforts, and I am proud to say that they have the support of the great majority of business men. It is not a selfish fight that the railroads are making, notwithstanding the fact that they are fighting for their very existence. It is a fight that concerns every business man as a user of railroad transportation. It is a fight for fundamental principles of government that are sound to the core.

The road to recovery may be a long one, and it may be a hard one, but it will be smoothed and our progress along it will be hastened to the extent that we remove the obstacles of excessive taxation and useless governmental expenditures.

The Fuel Engineering Company of New York, 116 E. 18th Street, has just issued an attractive booklet entitled "The Stream of Experience" to commemorate the completion of 25 years of service to their clientele. This booklet tells of the company's work in creating an expert service to coal buyers and how the facilities for this service have been developed to permit the determination of relative economic and performance values of virtually all the commercially important coals of the country. Over 112,000 separate coal analyses have been made, and for many years past these analyses have been classified according to common characteristics of the fuel, suitability for different types of firing and operating conditions, relative economic value, etc. The story of this company's service in the field of fuel engineering merits recording. Copies of their 25th anniversary booklet will be sent to those interested upon request.

The Brown Instrument Company, Philadelphia, announce that Nelson E. Chance, formerly district manager of the Houston office, has been appointed Assistant Sales Manager, with headquarters at Philadelphia. Mr. Chance has been with the Brown Company over ten years.

O. B. Wilson, formerly manager of the company's Cleveland, Ohio, office, will succeed Mr. Chance as district manager of the territory comprising Texas, Louisiana, and Southern Arkansas.

Stresses on Boiler Tubes Subjected to High Rates of Heat Absorption

By WM. L. DEBAUFRE

Chairman, Department of Applied Mechanics, The University of Nebraska

As the author states in his opening paragraph this article gives the substance of his paper presented, under the same title, at the recent annual meeting of the A.S.M.E. Previous investigations of stresses in boiler tubes have in general been based on approximate data and relations. In order to get a more accurate picture of the stresses in thick boiler tubes, subjected to high rates of heat absorption, the calculations made in this investigation were based on as nearly accurate experimental data as could be found for the mild steel used in boiler tubes and employed theoretically correct relations for the stresses in thick tubes. With respect to wall thickness, the results of the investigation indicate that the safest thickness of tube wall is that thickness where the ratio of the proportional-limit stress to the internal-pressure test is a maximum. Tests of 3 in. o.d. tubes of wall thicknesses from 1/8 to 5/8 in. under an internal steam pressure of 1390 lb. gage and at various heat absorption rates indicated in all cases that the safest ratio is for a greater thickness of tube wall than specified by the A.S.M.E. It was therefore concluded that making the tube thinner than called for by the A.S.M.E. Boiler Code would be a step in the wrong direction.

THE present article has been prepared to give the salient points in a paper of the same title presented at the annual meeting of the American Society of Mechanical Engineers in December, 1932. This paper was a contribution of the Technical Research Department of International Combustion Engineering Corporation by the head of the department based on reports dealing with various phases of the subject prepared by Messrs. R. H. Tilghman, G. H. Bierman, R. F. Nielsen and R. H. Luebbers, formerly members of that department. For a more detailed discussion of the procedure by which the various conclusions were reached and for derivations of the mathematical formulas involved, the reader is referred to the original paper.

Boiler Tube Temperatures for Various Rates of Heat Absorption

When heat is transferred through a boiler tube from the burning fuel and products of combustion to water boiling within the tube, the tube wall becomes hotter than the inclosed water-steam mixture. The temperature of the tube wall depends upon the rate of heat absorption, the dimensions of the tube, the thermal conductivity of the material, the temperature drop from the inner surface to the water boiling within the tube, and the pressure under which steam is being generated. The temperatures of the outside and inside surfaces of mild-steel boiler tubes are given from a report by Mr. Bierman in Tables 1, 2 and 3 for several rates of heat transfer, with 3-, 3.5- and 4-in. tubes such as might be used for the steam pressures tabulated, the thinnest tube wall corresponding to that specified by the A.S.M.E. Boiler Code.

In calculating the data for the above-mentioned tables, the temperature of saturated steam corresponding to a given gage pressure was taken from Keenan's "Steam Tables" published by the A.S.M.E. The temperature drop from the inner surface of the tube wall through the water film to the water boiling within the tube was based on a heat transfer factor of 3000 B.t.u. per hr. per sq. ft. per deg. fahr., a value which has been found to exist under favorable circumstances with clean surfaces. The temperature drop through the tube wall was based on the thermal conductivity of mild steel at the existing mean temperature of the metal as worked out by Messrs. Nielsen and Luebbers.

The data in Tables 1, 2 and 3 are of interest in showing the rise of the tube-wall temperature with higher steam pressures and with increased rates of heat absorption. In water-cooled furnaces, the rate of heat absorption in the first rows of the boiler tubes varies from 30,000 to 60,000 B.t.u. per hr. per sq. ft. In furnaces without water cooling, the rate of heat absorption in the first rows of boiler tubes may be higher and may reach 90,000 B.t.u. per hr. per sq. ft. due to the higher temperatures in refractory-lined furnaces. For a discussion of heat absorption by water-cooled surfaces exposed to radiation in a furnace, see the article entitled "Heat Absorption in Water-Cooled Furnace," in *Combustion*, January, 1931.

Calculated Stresses in a Thick Boiler Tube

When the temperature of a boiler tube is raised from room temperature to the operating temperatures as given in Tables 1, 2 and 3, the whole tube expands. Since the outer surface of the tube wall has a higher

operating temperature than the inner surface, the metal near the outer surface tends to expand more per inch of diameter than the metal near the inner surface. This produces a tensile stress in the metal near the inner surface of the tube wall and a compressive stress in the metal near the outer surface, which stresses may be called heat-transfer stresses because they arise from temperature differences accompanying heat transfer through the tube wall.

Due to the operating steam pressure within the tube, there is also a tensile stress throughout the tube wall, and this pressure stress is somewhat greater near the inner surface than near the outer surface.

TABLE 1 BOILER-TUBE TEMPERATURES (DEG F) FOR VARIOUS RATES OF HEAT ABSORPTION (3-IN. O. D. TUBES)

Gage pressure and corresponding saturated-steam temperature lb per sq in. and deg F	Wall thickness Gage no.	Wall thickness Inch	30,000 Inside surface	30,000 Outside surface	45,000 Inside surface	45,000 Outside surface	60,000 Inside surface	60,000 Outside surface	75,000 Inside surface	75,000 Outside surface	90,000 Inside surface	90,000 Outside surface
			Heat-absorption rate, Btu per sq ft of outside area per hr									
125 (352.86)	12	0.109	363.6	372.5	369.0	382.3	374.4	392.2	379.8	402.0	385.2	411.9
	11	0.120	363.7	373.5	369.2	383.8	374.6	394.2	380.0	404.6	385.5	414.9
	10	0.134	363.9	374.9	369.2	385.8	374.8	397.0	380.3	408.2	385.8	419.2
250 (406.02)	10	0.134	417.0	428.3	422.5	439.4	428.0	450.6	433.5	461.8	439.0	472.9
	9	0.148	417.1	429.5	422.7	441.2	428.2	453.0	433.8	464.9	439.3	476.6
	8	0.165	417.3	431.1	422.9	443.7	428.5	456.3	434.0	468.9	439.7	481.6
400 (448.12)	9	0.148	459.2	471.7	464.8	483.6	470.3	495.4	475.9	507.3	481.4	519.2
	8	0.165	459.4	473.4	465.0	486.0	470.6	498.8	476.1	511.3	481.8	524.2
	7	0.180	459.5	474.8	465.2	488.3	470.8	501.7	476.4	515.0	482.2	528.7
450 (459.50)	8	0.165	470.7	484.8	476.4	497.5	482.0	510.2	487.6	523.0	493.2	535.9
	7	0.180	470.9	486.3	476.5	499.7	482.2	513.2	487.9	526.8	493.6	540.4
	6	0.203	471.1	488.6	476.9	503.2	482.6	517.9	488.4	532.7	494.2	548.0
600 (488.77)	7	0.180	500.1	515.7	505.8	529.2	511.5	542.8	517.2	556.4	522.9	570.1
	6	0.203	500.3	518.0	506.1	532.8	511.9	547.6	517.7	562.4	523.5	577.3
	5	0.220	500.5	519.8	506.4	535.4	512.2	551.1	518.1	566.8	523.9	582.6
900 (533.87)	4	0.238	545.8	567.1	551.7	583.9	557.7	600.7	563.6	617.6	569.5	634.5
	3	0.259	546.0	569.4	552.0	587.3	558.1	605.3	564.1	623.3	570.1	641.5
	2	0.284	546.2	572.2	552.4	591.5	558.6	610.8	564.7	630.3	570.9	649.9
1350 (583.60)	0	0.340	596.5	629.0	603.0	651.8	609.5	675.0	615.9	693.7	622.4	721.4
	00	0.380	597.0	633.9	603.7	659.2	610.4	684.9	617.1	705.4	623.8	736.7
	000	0.425	597.6	639.6	604.5	667.8	611.5	696.5	618.5	725.4	625.5	754.7

TABLE 2 BOILER-TUBE TEMPERATURES (DEG F) FOR VARIOUS RATES OF HEAT ABSORPTION (3.50-IN. O. D. TUBES)

Gage pressure and corresponding saturated-steam temperature, lb per sq in. and deg F	Wall thickness Gage no.	Wall thickness Inch	30,000 Inside surface	30,000 Outside surface	45,000 Inside surface	45,000 Outside surface	60,000 Inside surface	60,000 Outside surface	75,000 Inside surface	75,000 Outside surface	90,000 Inside surface	90,000 Outside surface
			Heat-absorption rate, Btu per sq ft of outside area per hr									
125 (352.86)	11	0.120	363.6	373.3	369.0	383.5	374.3	393.8	379.7	404.1	385.1	414.4
	10	0.134	363.7	374.6	369.1	385.5	374.5	396.4	379.9	407.4	385.4	418.2
	9	0.148	363.8	375.9	369.2	387.4	374.7	398.9	380.2	410.5	385.6	422.1
250 (406.02)	9	0.148	416.9	429.2	422.4	440.8	427.9	452.5	433.3	464.2	438.8	475.8
	8	0.165	417.1	430.8	422.6	443.2	428.1	455.7	433.6	468.2	439.1	480.7
	7	0.180	417.2	432.2	422.8	445.4	428.3	458.6	433.9	471.8	439.5	485.0
400 (448.12)	8	0.165	459.2	473.0	464.7	485.6	470.2	498.1	475.7	510.7	481.2	523.4
	7	0.180	459.3	474.5	464.9	487.7	470.4	501.0	476.0	514.3	481.6	527.8
	6	0.203	459.4	476.7	465.1	491.1	470.7	505.5	476.4	519.9	482.1	534.6
450 (459.50)	7	0.180	470.7	485.9	476.2	499.2	481.8	512.5	487.4	525.9	493.0	539.3
	6	0.203	470.8	488.2	476.5	502.6	482.1	517.0	487.8	531.6	493.4	546.1
	5	0.220	470.9	489.8	476.7	505.1	482.4	520.4	488.1	535.8	493.8	551.2
600 (488.77)	6	0.203	500.1	517.6	505.7	532.1	511.4	546.6	517.1	561.3	522.7	575.9
	5	0.220	500.2	519.3	505.9	534.6	511.7	550.1	517.4	565.5	523.1	581.1
	4	0.238	500.3	521.1	506.1	537.4	511.9	553.7	517.7	570.1	523.5	586.6
900 (533.87)	2	0.284	545.8	571.4	551.8	590.3	557.8	609.2	563.7	628.3	569.7	647.7
	1	0.300	545.9	573.1	552.0	592.8	558.0	612.6	564.1	632.6	570.1	652.8
	0	0.340	546.3	577.5	552.5	599.4	558.7	621.5	564.9	643.7	571.1	666.2
1350 (583.60)	00	0.380	596.4	632.3	602.8	657.0	609.1	681.7	615.5	706.9	621.9	732.3
	000	0.425	596.8	637.8	603.4	665.1	610.0	692.8	616.6	720.8	623.2	749.1

TABLE 3 BOILER-TUBE TEMPERATURES (DEG F) FOR VARIOUS RATES OF HEAT ABSORPTION (4.00-IN. O. D. TUBES)

Gage pressure and corresponding saturated steam temperature, lb per sq in. and deg F	Wall thickness Gage no.	Wall thickness Inch	30,000 Inside surface	30,000 Outside surface	45,000 Inside surface	45,000 Outside surface	60,000 Inside surface	60,000 Outside surface	75,000 Inside surface	75,000 Outside surface	90,000 Inside surface	90,000 Outside surface
			Heat-absorption rate, Btu per sq ft of outside area per hr									
125 (352.86)	10	0.134	363.6	374.4	368.9	385.2	374.3	396.1	379.7	406.9	385.0	417.8
	9	0.148	363.7	375.7	369.1	387.1	374.5	398.6	379.9	410.1	385.3	421.5
	8	0.165	363.8	377.2	369.2	389.4	374.7	401.7	380.1	414.0	385.6	426.2
250 (406.02)	8	0.165	416.9	430.5	422.4	442.9	427.8	455.2	433.3	467.7	438.7	480.1
	7	0.180	417.0	431.9	422.5	445.0	428.0	458.0	433.5	471.2	439.0	484.3
	6	0.203	417.2	434.1	422.7	448.2	428.3	462.4	433.9	476.6	439.4	490.9
400 (448.12)	6	0.203	459.3	476.4	464.8	490.6	470.4	504.9	476.0	519.2	481.5	533.6
	5	0.220	459.4	478.0	465.0	493.1	470.6	508.2	476.2	523.3	481.8	538.5
	4	0.238	459.5	479.8	465.2	495.7	470.8	511.7	476.5	527.7	482.2	543.8
450 (459.50)	6	0.203	470.6	487.8	476.2	502.1	481.8	516.4	487.3	530.8	492.9	545.2
	5	0.220	470.7	489.5	476.4	504.5	482.0	519.7	487.6	534.8	493.2	550.1
	4	0.238	470.9	491.2	476.5	507.2	482.2	523.2	487.9	539.3	493.6	555.4
600 (488.77)	4	0.238	500.1	520.7	505.8	536.7	511.5	552.8	517.2	569.0	522.8	585.3
	3	0.259	500.3	522.8	506.0	539.9	511.8	557.1	517.5	574.3	523.2	591.7
	2	0.284	500.4	525.3	506.3	543.7	512.1	562.1	517.9	580.7	523.8	599.3
900 (533.87)	1	0.300	545.6	572.4	551.5	591.8	557.4	611.5	563.3	631.1	569.2	650.9
	0	0.340	545.9	576.7	552.0	598.2	558.0	620.1	564.0	641.9	570.0	663.8
	00	0.380	546.2	581.0	552.4	604.7	558.6	628.8	564.8	652.8	570.9	676.9
1350 (583.60)	000	0.425	596.3	636.4	602.7	663.2	609.0	690.2	615.4	717.6	621.7	745.2

Apparently, the total stress in the metal near the inner surface of the tube wall would equal the sum of the tensile stresses due to pressure and to heat transfer. Also, the net stress in the metal near the outer surface of the tube wall would equal the difference of the stresses due to pressure and to heat transfer and would be tension or compression depending upon whether the pressure stress or heat transfer stress is greater. To determine whether the stresses due to pressure and to heat transfer can be added or subtracted in this way, mathematical expressions were derived by Mr. Tilghman as given in the original paper, under the assumption that both pressure difference and temperature variation between the outer and inner surfaces of the tube wall exist simultaneously. These mathematical expressions were found to be made up of the sum of two terms, one of which corresponds to the stress for internal fluid pressure only while the other term corresponds to the stress for heat transfer only. Hence, it is permissible to calculate these two stresses separately and then add or subtract them to obtain the total or net stress in the tube wall.

Previous investigations of these stresses in boiler tubes have in general been based on approximate data and relations. In order to get a more nearly accurate picture of the stresses in thick boiler tubes subjected to high rates of heat absorption, calculations were made by Mr. Tilghman, using as nearly accurate experimental data as could be found for the mild steel used in boiler tubes and employing theoretically correct relations for the stresses in thick tubes. It was necessary to select proper values of the modulus of elasticity, the coefficient of thermal expansion, the coefficient of thermal con-

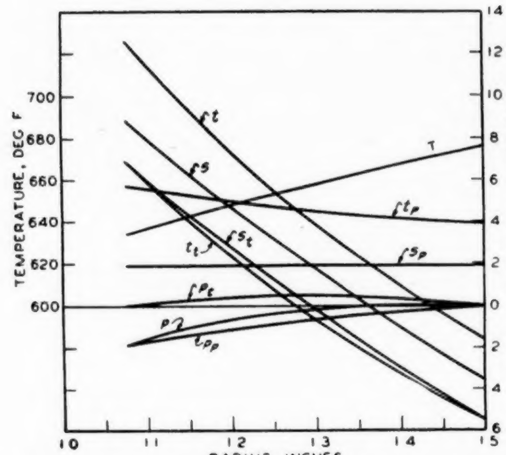


Fig. 1—Calculated stresses in tube wall for heat absorption of 30,000 B.t.u. per hr. per sq. ft.

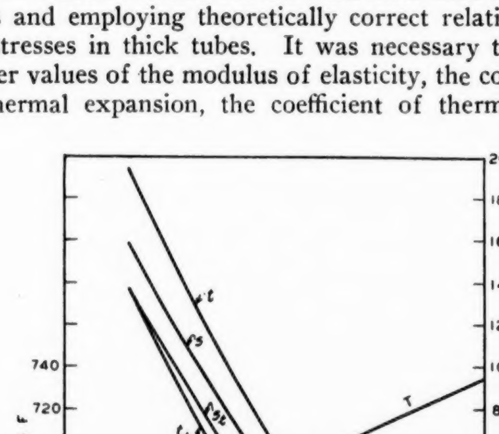


Fig. 2—Calculated stresses in tube wall for heat absorption of 60,000 B.t.u. per hr. per sq. ft.

ductivity and Poisson's ratio. The last mentioned quantity was taken as 0.30 while the values of the other three quantities were taken to correspond to the mean temperature in the tube wall. The coefficient of thermal expansion was based on studies by Mr. Luebbers; the coefficient of thermal conductivity was based on studies by Messrs. Nielsen and Luebbers. For the modulus of elasticity of mild steel at elevated temperatures, the modified Sutherland formula was used as given by Orrok in his paper on "High Pressure Steam Boilers" in the Trans. A.S.M.E. for 1928.

Calculations were made for the stresses throughout the metal wall of an exceptionally thick boiler tube required for a very high steam pressure, 1840 lb. gage. The outside diameter of this tube is 3 in. and its thickness is 0.425 in., so that the outer radius of the tube is 1.5 in. and its inner radius is 1.075 in. The calculated stresses from the outer to the inner radius, are shown in Figs. 1, 2 and 3 for rates of heat absorption of 30,000, 60,000 and 90,000 B.t.u. per hr. per sq. ft. of outside surface respectively. The temperatures within the metal of the tube wall are also shown in Figs. 1, 2 and 3 for the several rates of heat absorption by the curves marked T. The maximum and minimum temperatures are as follows:

Rate of heat absorption, B. t. u. per hr. per sq ft.	Saturated steam temp., deg. fahr.	Temperature of inside surface, deg. fahr.	Temperature of outside surface, deg. fahr.
30,000	620	634.0	676.5
60,000	620	647.9	734.1
90,000	620	661.9	792.5

The stresses for both internal fluid pressure and heat transfer were calculated in the three principal directions, namely, circumferentially, axially and radially. The circumferential stress acts in the direction of the tangent to the circumference of the tube and tends to burst the tube with a longitudinal rent. The axial stress acts parallel to the axis of the tube and tends to rend it apart along a plane perpendicular to the axis. The radial stress acts in a radial direction.

The radial stress due to internal fluid pressure only is designated as p_p in Figs. 1, 2 and 3, and varies from a compressive stress equal to the internal fluid pressure of 1840 lb. per sq. in. at the inside surface of the tube wall to practically zero at the outside surface. The axial tensile stress s_p due to internal fluid pressure only is constant over the tube-wall cross-section and equals 1943 lb. per sq. in. The circumferential tensile stress t_p due to internal fluid pressure only varies from a maximum of 5726 lb. per sq. in. at the inside surface to a minimum of 3886 lb. per sq. in. at the outside surface. These stresses due to internal fluid pressure only are the same in Figs. 1, 2 and 3.

The stresses due to heat transfer only differ greatly in Figs. 1, 2 and 3 for the three rates of heat absorption assumed. The radial stress p_t due to heat transfer only is zero at both the inside and outside surfaces; within the tube wall, the metal is in tension radially, but the maximum tension is small even with high rates of heat absorption. In general, the axial and circumferential stresses s_t and t_t due to heat transfer only vary from the same maximum tensile stress at the inside surface to the same maximum compressive stress at the outside surface, but do not coincide at points within the tube wall. The maximum tensile stress at the inside

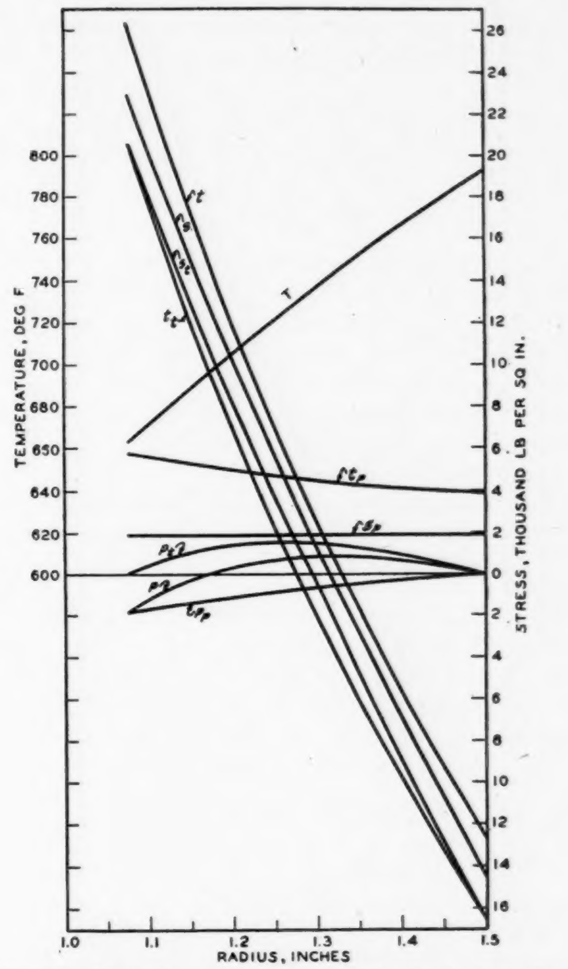


Fig. 3—Calculated stresses in tube wall for heat absorption of 90,000 B.t.u. per hr. per sq. ft.

surface is greater than the maximum compressive stress at the outside surface as shown in the following table:

Rate of heat absorption, B.t.u. per hr. per sq. ft.	Maximum circumferential and axial tensile stress at inside surface, lb. per. sq. in.	Maximum circumferential and axial compressive stress at outside surface, lb. per sq. in.
30,000	6,841	5,486
60,000	13,721	11,004
90,000	20,618	16,536

Adding the stresses due to internal fluid pressure and to heat transfer, we find the total radial, axial and circumferential stresses throughout the tube wall to be as represented by the curves p, s, and t respectively in Figs. 1, 2 and 3. In any other direction than these three principal directions, the magnitude of the stress lies between the values shown in the radial, axial and circumferential directions. The total circumferential stress at the inside surface of the tube wall is the greatest stress in the material. The total circumferential stress t varies from this maximum value in tension at the inside surface through zero at a point within the tube wall to a much lower value in compression at the outside surface. The total axial stress also has a maximum value at the inside surface of the tube wall and varies from this maximum value in tension at the inside surface to a lower maximum value in compression at the outside surface. The total radial stress p is low and will not receive further consideration.

The maximum values calculated for the total circum-

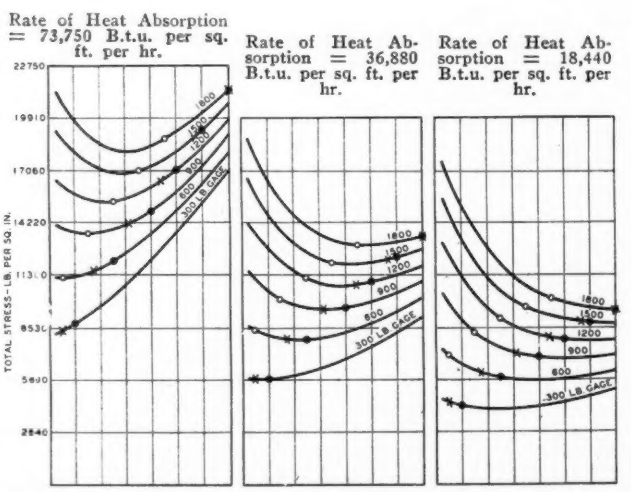
ferential and axial tensile stresses at the inside surface of the tube wall are as follows:

Rate of heat absorption, B.t.u. per hr. per sq. ft.	Maximum circumferential tensile stress, lb. per. sq. in.	Maximum axial tensile stress, lb. per sq. in.
30,000	12,567	8,784
60,000	19,447	15,664
90,000	26,344	22,561

Apparently, the calculated stresses reach very high values in thick boiler tubes subjected to high rates of heat absorption. These values calculated by means of theoretically correct mathematical expressions based on the theory of elasticity for thick tubes, are higher than the values calculated with the approximate mathematical relations previously used for this purpose.

If the tube wall were very thin, it is evident that the heat-transfer stress would be low but the internal-fluid-pressure stress might be so high as to cause failure of the tube. By making the tube wall slightly thicker, the internal-pressure stress would be greatly decreased without much increase in the heat-transfer stress, so that the total stress would be less than for the very thin tube. If the wall thickness were increased still further, it is conceivable that the heat transfer-stress might be considerably increased without much further reduction in the internal-pressure stress so that the total stress might be increased over that with a somewhat thinner tube. In other words, there would be a certain thickness of tube wall for which the total stress would be a minimum. Previous calculations with approximate relations have shown this minimum calculated stress to occur with tubes thinner than specified by the A.S.M.E. Boiler Code and calculations with the more nearly exact relations used to determine the stresses in Figs. 1, 2 and 3 would undoubtedly show the same result.

For this reason, it has been suggested that it would be desirable to use thinner tubes than called for in the A.S.M.E. Boiler Code in order to reduce the total stresses due to internal fluid pressure and heat transfer. As pointed out by Dr. D. S. Jacobus in discussing the original paper, "The new German rules, enacted by the



Points marked by solid circles are for the old German rules, points marked by hollow circles are for the new German rules for steel having a tensile strength of from 49,800 to 64,000 lb. per sq. in., and points marked by the crosses are for the new A.S.M.E. Boiler Code Rules (from discussion of Dr. D. S. Jacobus).

Fig. 4—Comparison of tube wall thickness required by the old and new German rules and by the A.S.M.E. Code.

Imperial Minister of Public Works, July 13, 1931, sanction the use of thinner tubes than those specified in the old German rules or in the A.S.M.E. Code. This was done with the idea of securing improved results, especially at high rates of heat transfer. . . . The new German rules were prepared by a Subcommittee of the German Steam Boiler Code Committee of the Vereinigung der Grosskesselbesitzer e.V. (Association of Boiler Proprietors, Incorporated). An abstract of an article by E. Lupberger entitled 'Discussion of Heated Tubes in High Pressure Boilers' appeared in the December, 1931, issue of *Mechanical Engineering.* This article contained diagrams which showed the stresses in a tube 83 mm. = 3.27 in. outside diameter when subjected to radiant heat. The diagrams gave the stresses for various wall thicknesses and for three rates of heat

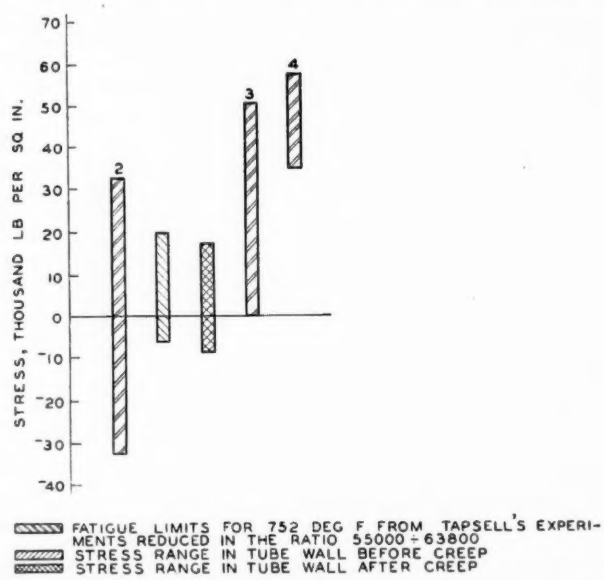


Fig. 5—Comparison of circumferential-stress ranges for heat absorption of 90,000 B.t.u. per hr. per sq. ft. with fatigue-test data.

transfer. The stresses for the different rates of heat transfer were computed on the basis of the elastic theory."

The diagrams mentioned are reproduced in Fig. 4 with the tube thicknesses required by the A.S.M.E. Boiler Code rules marked thereon (crosses) by Dr. Jacobus as well as showing the tube thicknesses required by the old German rules (solid circles) and by the new German rules (open circles) for mild steel having a tensile strength from 49,800 to 64,000 lb. per sq. in. Still thinner tubes are permitted with steel having a tensile strength from 64,000 to 78,000 lb. per sq. in.

The maximum stresses in Fig. 3 and in Fig. 4, although calculated on the assumption of perfect elasticity, exceed the proportional limit and even the elastic limit of mild steel at the operating temperatures given in Tables 1, 2 and 3. Hence these calculated stresses will not be reached by reason of plastic flow in the tube wall adjacent to the inside surface where the maximum calculated stresses occur.

Probable Stresses in a Thick Boiler Tube

The original paper contains a lengthy discussion, worked out by Mr. Tilghman, of how plastic flow, in reducing the maximum stresses near the inside surface,

raises slightly the stresses in the remainder of the tube wall where the elastic limit of the material is not exceeded and also produces a residual stress which is greatest near the inside surface where the largest plastic flow occurred. This plastic flow is due first to the initial creep which occurs as soon as the stress exceeds the elastic limit of the material. Secondary creep then occurs as time goes on and further reduces these stresses until ultimately they are reduced to the creep limit stress or change so slowly as not to be noticeably lowered over a long period of time.

There are, of course, two schools of thought with regard to secondary creep. One school considers that creep does not occur below a certain limiting stress corresponding to the temperature of the material. The other school considers that creep continues indefinitely at all temperatures and stresses, but at a rate which becomes less and less as the temperature and stress decrease.

To the extent, however, that the operating stress in tension near the inside surface of a boiler tube is relieved by creep, a residual compressive stress is set up at the same place when the boiler goes out of operation. The material in a boiler tube thus undergoes a stress cycle from tension to compression as the boiler goes alternately into and out of operation. While, by reason of plastic flow, the curves in Figs. 3 and 4 do not represent the maximum operating stresses reached in boiler tubes near the inside surface, they do represent the maximum stress ranges to which the tubes are subjected as the boiler goes into and out of operation. Not

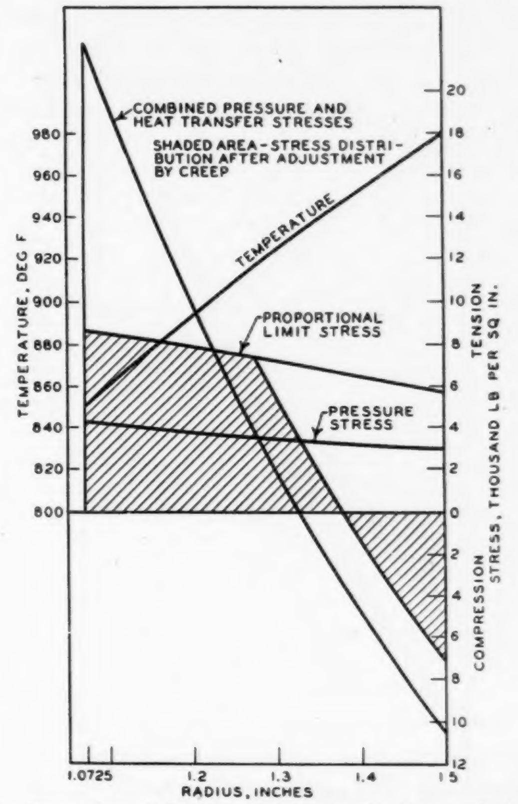


Fig. 7—Circumferential stress distribution in tube wall for heat absorption of 90,000 B.t.u. per hr. per sq. ft. with 224.6 fahr. temperature drop through water film.

only is this true for the stresses near the inside surface of the tube wall, but the curves in Figs. 1, 2 and 3 indicate the stress ranges throughout the tube wall.

Another part of the original paper, also worked out by Mr. Tilghman, deals with the axial stresses in a thick boiler tube heated on one side only. It was concluded that only under abnormal conditions of abruptness in change of the rate of heat transfer around the tube will the axial stress range at the inner and outer surfaces exceed the circumferential stress range at the inner surface.

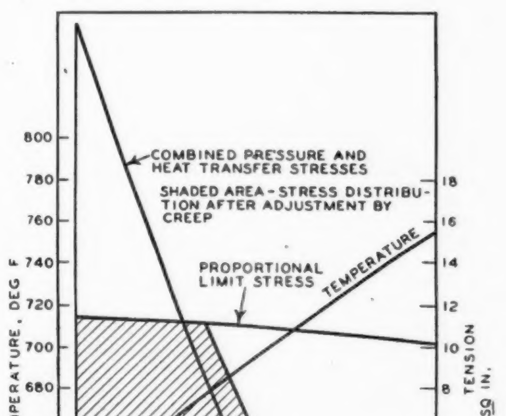


Fig. 6—Circumferential stress distribution in tube wall for heat absorption of 90,000 B.t.u. per hr. per sq. ft. with 41.9 fahr. temperature drop through water film.

Fatigue Strength of Thick Boiler Tubes

That the mere stressing of a boiler tube beyond the elastic limit of the material near the inner and outer surfaces of the tube wall is not injurious to the tube becomes evident when we consider that stressing beyond the elastic limit is done purposely in many manufacturing operations of rolling, drawing and spinning in order to improve the material by raising its elastic limit and ultimate strength. It is well known, for example, that cold-drawn wire has a higher elastic limit and a greater tensile strength than the ingot from which it was made. Helical steel springs are purposely overloaded in order to stress a portion of the material beyond the elastic limit and give it a permanent set so that the springs will thereafter bear a greater load without permanent deflection and without failure by fatigue than they would if they had not been so overloaded. In boiler tubes subjected to high rates of heat absorption, this improvement in the material is automatically accomplished by the conditions of service rather than requiring a separate manufacturing operation to accomplish it.

The portion of the mild steel in a boiler tube wall

which has been loaded beyond the elastic limit, has a new elastic limit higher than the original elastic limit of the material. So long as the working stress does not exceed the new elastic limit, there will be elastic deformation of the material in proportion to the stress. Due to the permanent set acquired by portions of the tube wall being stressed beyond the elastic limit and to other portions not being stressed beyond the elastic limit, the stress will be reversed when heat transfer ceases and the internal fluid pressure is reduced to zero.

For the particular tube studied, the calculated circumferential tensile stress at the inner surface of the tube wall for the internal fluid pressure of 1840 lb. gage and a heat absorption rate of 90,000 B.t.u. per hr. per sq. ft. of outside tube surface, was found to be about 26,300 lb. per sq. in. This stress is not reached, however, due to plastic flow. Primary creep reduces this tensile stress to about 20,000 lb. per sq. in. with a residual compressive stress of about 6,300 lb. per sq. in. If secondary creep should occur to the creep limit, this tensile stress would be further reduced to about 17,400 lb. per sq. in. with a residual compressive stress of about 8,900 lb. per sq. in.

In Fig. 5, taken from the original paper, these stress ranges are compared with test data by Tapsell on the stress ranges which may be repeated ten million times without failure of mild steel at about the temperature of boiler tubes. If the boiler tube passed through one cycle per day, it would require

27,400 years to complete 10,000,000 cycles
2,740 years to complete 1,000,000 cycles
274 years to complete 100,000 cycles.

Thus, even if at this slow rate of reversal, the number of reversals permissible should be much less than that found by test with a rapid rate of stress reversal, boiler tubes should last many years so far as any stresses due to a high rate of heat absorption is concerned.

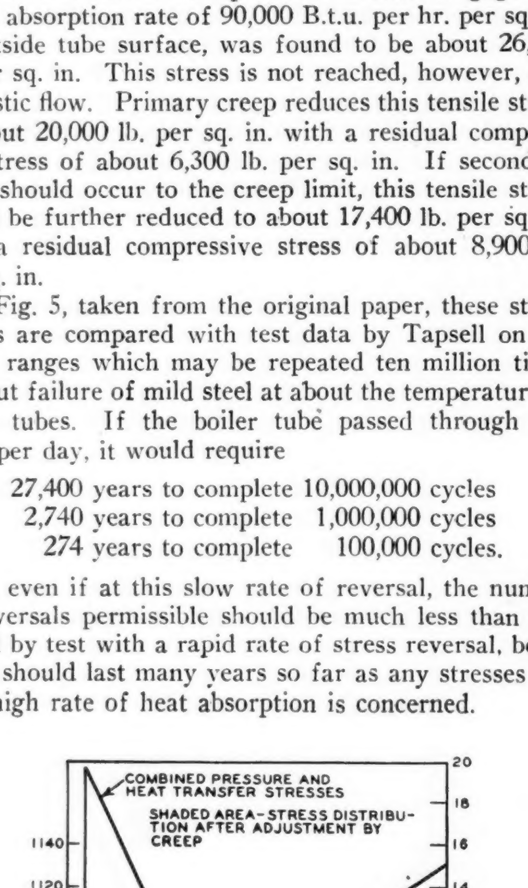


Fig. 8—Circumferential stress distribution in tube wall for heat absorption of 90,000 B.t.u. per hr. per sq. ft. with 374.6 fahr. temperature drop through water film.

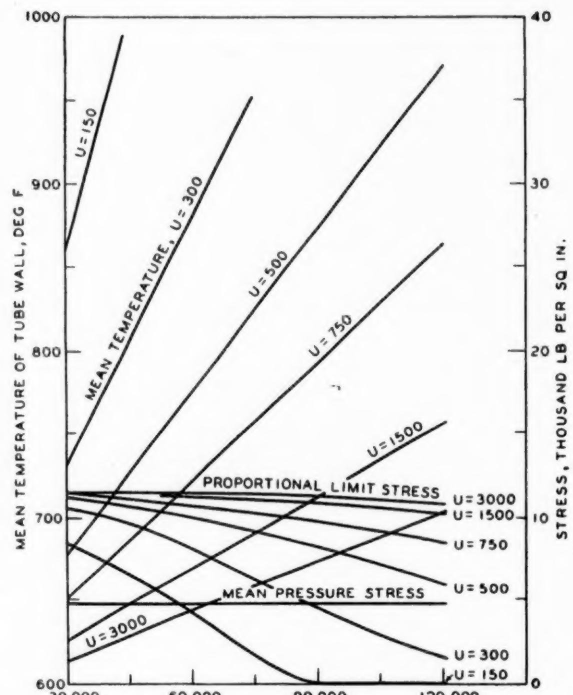


Fig. 9—Variation of mean temperature and corresponding proportional-limit stress with heat absorption in a 3-in. mild-steel tube with wall 0.344 in. thick.

In discussing the original paper, Mr. G. A. Orrok, pointed out that there were parts of a boiler where similar stress cycles were occurring all the time and that these points would be subject to fatigue.

It may also be necessary to consider corrosion fatigue discovered by Dr. McAdam; for when steel is subject to corrosion, the stress range that can be withstood ten million times is greatly reduced. No boiler tube failure can be attributed to heat transfer stresses, however, unless the fracture is typical of fatigue conditions.

Bursting of Thick Boiler Tubes by Internal Pressure

Before a boiler tube can fail by bursting, all portions of the tube wall must be stressed to a point where more or less rapid creep will occur to rupture. Before this can take place, all heat-transfer stresses will be entirely neutralized by plastic flow. Failure of the tube will then be caused by the stresses due to internal fluid pressure only. These conclusions were derived by Mr. Bierman and may be demonstrated by reference to Figs. 6, 7 and 8.

While the boiler tube in Figs. 6, 7 and 8 is of the same dimensions as in Figs. 1, 2 and 3, the steam pressure is 1390 lb. gage instead of 1840 lb. gage for the reason that Figs. 6, 7 and 8 were originally made for a study of a different installation than Figs. 1, 2 and 3. The circumferential stresses only have been considered in Figs. 6, 7 and 8 because, as mentioned previously, the axial stresses are less than the circumferential stresses except with an abnormally non-uniform heat absorption around the tube.

Referring to Figs. 6, 7 and 8, the difference of the areas above and below the zero line to the curve for combined pressure and heat-transfer stresses must equal the area under the line for pressure stress only because the total stress in the tube wall must balance the

same total internal fluid pressure whether heat is being transferred or not. These stress lines were determined in accordance with the theory of elasticity of materials. Due, however, to the maximum values of these calculated stresses being above the elastic limit of the material, plastic flow will occur to reduce these maximum stresses to much lower values. Eventually, these stresses would all be reduced to the creep-limit stress at the operating temperature at each point in the tube wall. At low temperatures, the creep-limit stress is above the proportional-limit stress of mild steel; while at high temperatures, the reverse is true. For the purpose of this discussion, the proportional limit stress has been taken as the stress to which all higher stresses are eventually reduced by plastic flow.

Curves representing the proportional-limit stress of mild steel at the varying temperature in the tube wall were drawn above and below the zero line to represent the limiting stresses in the tube wall. Wherever the calculated stress exceeded the proportional-limit stress, it was reduced to that limiting value; but to compensate for this reduction in stress adjacent to the inner surface

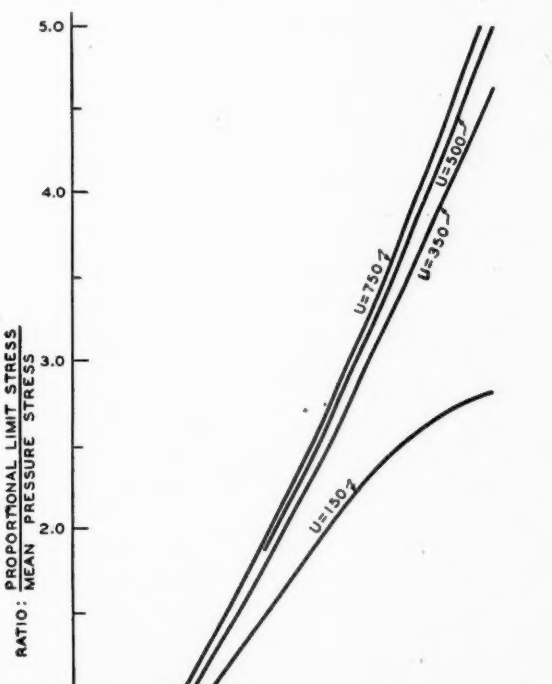


Fig. 10—Variation of safety factor with tube-wall thickness for heat absorption of 30,000 B.t.u. per hr. per sq. ft. with different coefficients of heat transfer through water film.

of the tube wall, the stresses at other points within the tube wall were increased. Compensation is evidently complete when the combined stress line is moved up until the difference of the cross-sectioned areas above and below the zero line just equals the area under the pressure-stress line.

The temperature and corresponding proportional-limit curves in Figs. 6, 7 and 8 were drawn for three different coefficients of heat transfer from the inner surface of the tube wall to the water-steam mixture within the tube with the same rate of heat absorption, 90,000 B.t.u. per hr. per sq. ft. The effect of an increase

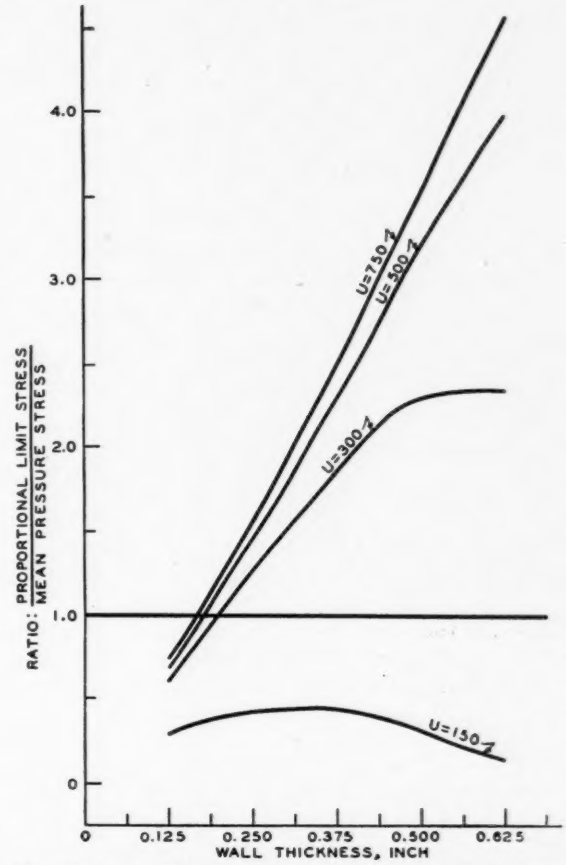


Fig. 11—Variation of safety factor with tube-wall thickness for heat absorption of 60,000 B.t.u. per hr. per sq. ft. with different coefficients of heat transfer through water film.

in temperature drop through the water film from 41.9 deg. fahr. to 224.6 deg. fahr. and finally to 374.6 deg. fahr. is to move the proportional-limit stress curve toward the pressure-stress curve. Under the final condition, the tube is just about to fail because the tube-wall temperature has increased until the stress due to internal fluid pressure exceeds the creep-limit stress of the material, which is below the proportional-limit stress at these high temperatures. Before this condition has been reached, all heat-transfer stresses have evidently been neutralized by creep.

A measure of safety of the boiler tube is the ratio of the proportional-limit stress (or creep-limit stress) of the material of the tube wall at the mean operating temperature to the mean stress due to internal fluid pressure. When this ratio equals unity, the tube is about to burst by its internal pressure.

Safest Thickness of Boiler Tube Wall

In a thin-walled tube the stresses due to internal fluid pressure are high so that the ratio of the proportional-limit stress at the mean wall temperature to the mean-internal-pressure stress may be low and the tube unsafe. As the thickness is increased, the pressure stress is considerably decreased at first without much change in the proportional-limit stress. It is conceivable, how-

ever, that a large increase in thickness with a high rate of heat transfer might cause the mean temperature of the tube wall to become so high that the safety of the tube would be decreased in spite of the decrease in internal-pressure stress. The safest thickness of tube wall is that thickness where the ratio of the proportional-limit stress to the internal-pressure stress is a maximum.

For a given tube material, the safest thickness will depend upon the coefficient of heat transfer from the inner surface of the tube wall to the water-steam mixture within the tube, as well as upon the rate of heat absorption. To determine how this safest thickness compares with that specified in the A.S.M.E. Boiler Code, calculations were made for wall thicknesses from 1/8 in. to 5/8 in. for a 3-in. outside-diameter mild-steel tube under an internal stream pressure of 1390 lb. gage. Heat-absorption rates of 30,000, 60,000, 90,000 and 120,000 B.t.u. per hr. per sq. ft. and film coefficients of 3000, 1500, 750, 500, 300 and 150 B.t.u. per hr. per sq. ft. per deg. fahr. were assumed. The thickness specified by the A.S.M.E. Boiler Code for an internal steam pressure of 1390 lb. gage is 0.312 in.

For each tube-wall thickness, the mean wall temperature, corresponding proportional-limit stress, and mean-pressure stress were plotted as shown in Fig. 9 for an 0.344-in. wall. Then the ratio of proportional-limit stress to mean-pressure stress was plotted in Figs. 10 to 13, for the four assumed rates of heat absorption. In all cases the safest ratio is for a greater thickness of tube wall than specified by the A.S.M.E. Boiler Code.

Fig. 12—Variation of safety factor with tube-wall thickness for heat absorption of 90,000 B.t.u. per hr. per sq. ft. with different coefficients of heat transfer through water film.

It was therefore concluded that making the tube thinner than called for by the A.S.M.E. Boiler Code would be a step in the wrong direction.

"Unfortunately," as mentioned by Mr. Orrok, "the greater thickness of tube metal is not a guarantee against the effects of scale accumulations, poor circulation, flame impingement and their consequent troubles." The use of thinner tubes than specified by the A.S.M.E. Boiler Code has a number of advantages as listed by the author of the article referred to by Dr. Jacobus; and the practical results of the German experiment in using such tubes will undoubtedly be watched with interest by all manufacturers and users of high pressure steam boilers. One practical disadvantage to the use of thin tubes is the absence of any margin of safety where corrosion is liable to occur.

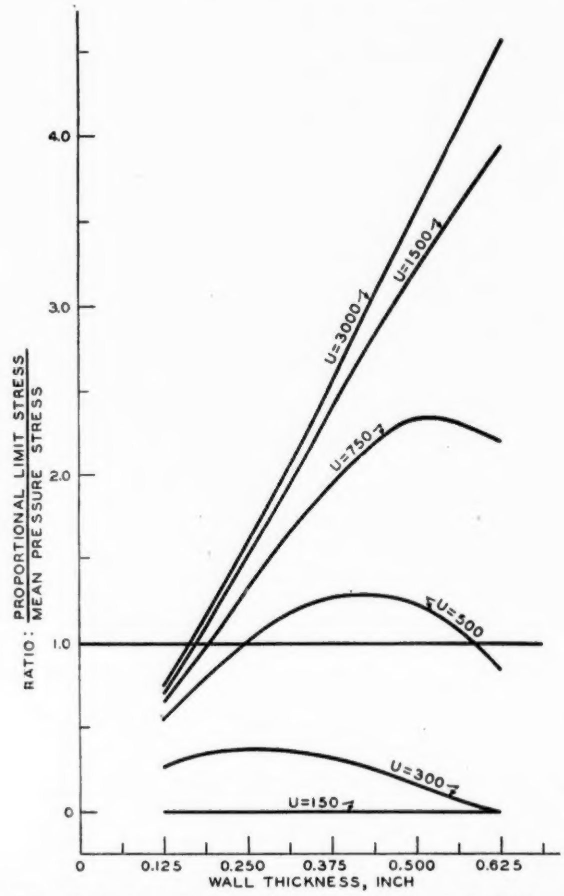


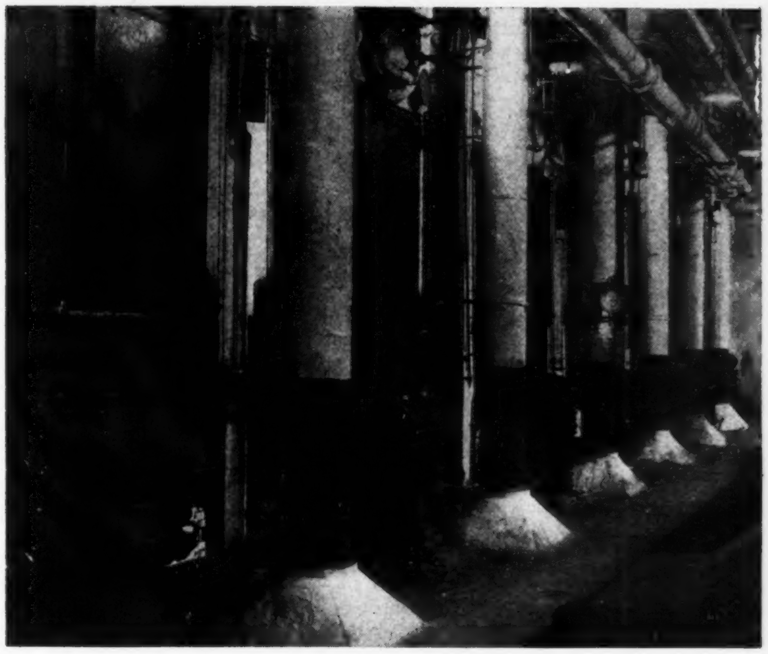
Fig. 13—Variation of safety factor with tube-wall thickness for heat absorption of 120,000 B.t.u. per hr. per sq. ft. with different coefficients of heat transfer through water film.

The safety of a boiler tube may also be increased by using a material having a higher proportional-limit stress, such as medium- instead of low-carbon steel. The thermal conductivity would be but slightly changed by the higher carbon content so that the effect of the higher proportional-limit stress would not be appreciably counteracted by higher operating temperatures. Even with mild steel, however, the curves of Figs. 10 to 13 show that failure can occur only when the coefficient of heat transfer from the inner surface of the tube wall to the water-steam mixture within the tube is reduced to an abnormally low value by poor circulation within the tube or by scale accumulations on the tube wall unless the material is defective or corrosion occurs.

Modern Results From an Old Plant

By
R. D. MYERS[1]

The title of this article, while literally true, should not be interpreted by those who are operating obsolete equipment as indicating a possibility of obtaining modern results from such equipment. To begin with the stokers used in this plant are of a design that is as fundamentally sound and efficient today as the day they were installed. Then the equipment was properly maintained and as worn-out parts were replaced, advantage was taken of improvements in detail which would contribute to more efficient operation. In other words, the equipment itself was always potentially capable of producing results comparable with those being obtained in current practice, as long as it was kept in good repair and intelligently operated. The improvement obtained during the past year has been due to excellent operation, a novel arrangement for preheating combustion air and the use of modern instruments which have given a constant check on performance. In these respects, the story of this plant holds an important lesson for those who have equipment, which, while old in point of years, is capable of yielding better results than are being obtained. The requirements obviously are,—intelligent analysis to determine what can be done to improve operation, persistence in carrying out the indicated steps, the installation of the necessary instruments to guide and check the operators and, finally, proper maintenance of the equipment.



Photograph taken before installation of boiler meters. Meters were installed on alternate columns.

A RECORD of exceptional economies obtained in an old boiler plant should be of interest especially in these days when many plant operators are confronted with the necessity of effecting further economies with their present equipment.

The plant under discussion was built in 1908. Five B. & W. water tube boilers, of 4,000 sq. ft. of heating surface each, were installed and equipped with hand-fired furnaces to burn anthracite. In 1912, Type E Underfeed Stokers were installed. This was the second Type E Stoker installation in the United States and as the first installation is no longer operating, it is now the oldest in this country.

Table 1 gives test data obtained when the stokers were installed indicative of performance under test conditions at that time. In 1918 due to increased load demands two more boilers of the same size and type were installed and equipped with Type E Stokers. The years that followed were difficult. Labor turnover was so high that it was impossible to build up an efficient organization. The coal obtainable was of indifferent quality and its delivery was problematical, which necessitated having a large reserve supply with much added expense for handling. The delivery of repair materials was delayed. Equipment could not be maintained at its highest operating efficiency; all of which is reflected in the cost data.

Many things were done to stabilize labor. New locker rooms equipped with showers, two lockers for each man

[1] Chief Operating Engineer of the plant described, the name of which is withheld in compliance with the company's policy.

—one for street clothes and one for working clothes; tables with benches where each man could sit in comfort to eat his lunch and rest; shorter hours and more pay. All these things had the desired effect and eventually we were able to build up a very fine organization.

The solving of the problem of better ventilation of the boiler room gave us a big surprise. The boiler room occupies one-half of the basement of the building and is separated from the other half by a curtain wall with a large fireproofed rolling door between the two rooms. Ventilation for the boiler room is provided by fan-lights at the ceiling, opening at the street level and placed along the entire side of the building at the front of the boilers. The forced draft fan taking air from the boiler room at the floor level created fairly satisfactory ventilation as long as the communicating door in the wall at the rear of the boilers, remained closed. With this door open—its location being adjacent to the fan room—the circulation of air was short circuited and the firing aisle at the front of the boilers became more or less of a dead pocket.

Here is where the human element had to be dealt with. It was found impossible to make the average fireman believe that the door being closed added to his comfort, even though a thermometer placed in the firing aisle would show a drop of from eight to ten fahr. by closing the door. He would feel the in-rush of cool air when he opened the door and neither the evidence of the thermometer nor any other argument would convince him that someone was not trying to roast him.

To improve this condition we closed off the fan room, causing the fan to draw its supply of air from near the boiler room ceiling. The air drops from the street level

TABLE 1—RESULTS OF OLD TESTS*

Date of test	Oct. 1, 1913	Oct. 3, 1913	Oct. 17, 1913
Test to determine	capacity	economy	economy
Duration of test—hr.	6	8	8
Steam pressure—lb. gage	160-165	160-165	160-165
Forced draft—in. water..	3-3½	2-2½	1.8
Draft over fire—in. water	.12	.02-.08	.02
Feedwater temp.—deg. fahr.	61	60	58
Average CO_2—per cent ...	...	11.4	12.3
Flue gas temp.—deg. fahr.	600	520	503
Moisture in coal as fired—%	4.65	4.66	4.00
Total coal fired (wet)—lb.	14,925	12,000	11,925
Total water evaporated—lb.	121,250	100,625	101,250
Water evaporated per lb. coal as fired	8.12	8.38	8.49
Water evaporated per lb. dry coal—lb.	8.52	8.79	8.844
Factor of evaporation	1.207	1.208	1.21
Water evap. from and at 212 deg. fahr. per lb. of coal as fired—lb.........	9.80	10.12	10.27
Water evap. from and at 212 deg. fahr. per lb. of dry coal—lb.	10.283	10.62	10.70
Water evap. from and at 212 deg. fahr. per lb. of dry coal, deducting hp. used by F.D. equip.—lb..	10.07	10.46	10.52
Net evap. from and at 212 deg. fahr. **Basis of** coal 14500 B.t.u.	10.55	10.9	10.95
Hp. developed—(gross) ..	707	440	443.8
(net)	693	432	437
% builders rating (gross)	176.7	110	110.9
(net)..	173.2	108	109
Combined efficiency (gross)	71.4	73.7	74.1
(net)..	70.3	72.6	73.1
Analysis of coal—as fired			
Moisture	4.65	...	4.00
Ash	9.64	...	11.59
Volatile	24.40	...	24.74
Fixed carbon	61.31	...	59.67
Sulphur	undet.	...	1.76
B.t.u.	13,400	...	13,400
Dry basis			
Ash	10.11	...	12.07
Volatile	25.59	...	25.77
Fixed Carbon	64.30	...	62.16
Sulphur	undet.	...	1.83
B.t.u.	13,930	...	13,940

* In comparing these results with those given in Table 2, it should be remembered that average operation at the time was much inferior to average operation in recent years. While the results shown in Table 2 checks closely with current average operating results, this was not true of the above results.

TABLE 2—RESULTS OF RECENT TESTS

Data and results of evaporative test of the No. 1 water tube boiler and stoker to determine efficiency under actual operating conditions.

Date of test	June 10, 1932
Duration of test—(hr.)	8
Dimensions and proportions	
Grate surface—(sq. ft.)	72.5
Height of furnace at nearest point of grates to tubes—(ft./in.)	3/6
Boiler heating surface—(sq. ft.)	4000
Superheating surface	None
Volume of combustion space—(cu. ft.)	308
Furnace volume per sq. ft. of boiler heating surface—(cu. ft.)	0.077
Average steam pressure—(lb.)	160
Average temperature	
Air in fire room—(deg. fahr.)	82
Feedwater entering boiler—(deg. fahr.)	56
Gases escaping from boiler—(deg. fahr.)	520
Fuel	
Kind	Bituminous Coal
Total weight of coal as fired—(lb.)	12,205
Moisture in coal as fired—(per cent)	6.32
Total weight of dry coal—(lb.)	11,434
Total weight of ash and refuse (removed from ash pit)—(lb.)	909

Proximate Analysis of Coal

	Coal as fired per cent	Dry coal per cent	Combustible per cent
Moisture	6.32	0.00	0.00
Volatile matter	20.26	21.65	23.20
Fixed carbon	67.41	71.90	76.80
Ash	6.01	6.45	0.00
	100.00	100.00	100.00

Analysis of ash	
Combustible matter—(per cent)	27.66
Incombustible matter—(per cent)	72.34
Heat value of coal B.t.u. per lb. as fired	13,685
Hourly quantities	
Fuel as fired per hr.—(lb.)	1525.6
Dry fuel per hour—(lb.)	1429
Fuel as fired per sq. ft. of grate per hr.—(lb).	21
Dry fuel per sq. ft. of grate per hr.—(lb.)	19.8
Combustion space per lb. coal per hr. (dry)—(cu. ft.)	0.215
Refuse per hour—(lb.)	114
Actual water per hr.—(lb.)	14,149
Factor of evaporation	1.1902
Equivalent evaporation per hr.—(lb.)	16,840
Moisture in steam—(per cent)	2.0
Superheat	None
Total weight of water fed to boilers—(lb.)	113,192
Developed hp. per hr.	488
Boiler rating—(hp.)	400
Per cent of boiler rating	122
Water apparently evaporated (actual conditions) per lb. coal as fired—(lb.)	9.27
Actual equivalent evaporation per lb. coal as fired—(lb.)	11.04

Boiler and stoker efficiency=

$$E = \frac{11.04 \times 970.4}{13,685} \times 100 = 78.28 \text{ per cent}$$

HEAT BALANCE

	B.t.u.	Per cent
Heat absorbed by water and steam in boiler	10,713	78.28
Heat loss due to moisture in coal	89	0.07
Heat loss due to combustion of hydrogen	536	4.00
Heat loss due to dry chimney gases	1,422	10.75
Heat loss due to unconsumed combustible in ash	331	2.5
Heat loss due to radiation and unaccounted for	594	4.4
Total	13,685	100.0

through the fanlights, sweeps the firing aisle and, coming in contact with the boilers, is heated, rises to the ceiling and is carried off by the forced draft fan. The passage of this air from the ceiling to the fan is through a space 18 in. wide by 14 ft. long between the flue gas duct at the rear of the boilers and the rear wall of the boiler room. By removing the lagging from that part of the flue gas duct contacted by the air in its passage to the fan, we formed an air preheater which delivered air to the fan at a temperature of from 125 deg. fahr. in the cold weather to 150 deg. fahr. in the warmer weather. The gain in thermal efficiency is less than one per cent and here is where the surprise came. As soon as we put the air preheater to work our efficiency started to climb. Tests with the orsat showed that the fires could be run with much less excess air than formerly. The CO_2 changed from 12 per cent to 15 per cent average and we found we could carry the CO_2 content up to 16 per cent with only a trace of CO. By increasing the temperature of the air we increased its volume so that the pressure differential through the fuel bed was maintained with a smaller quantity of air. At the time we put the preheater to work we were able to get an appropriation for Bailey Boiler Meters for indicating the flow of steam, air and the temperature of the flue gas. The meters were installed and put into operation in September, 1931, and proved invaluable in showing adverse conditions and improper practices.

Table 2 presents the results of a test run on one of these boilers in June, 1932, under normal operating conditions, with the only changes those necessary to weigh the coal, ashes and water fed into the boiler. The fireman handled this stoker along with those under the other boilers on the line in routine manner. A compari-

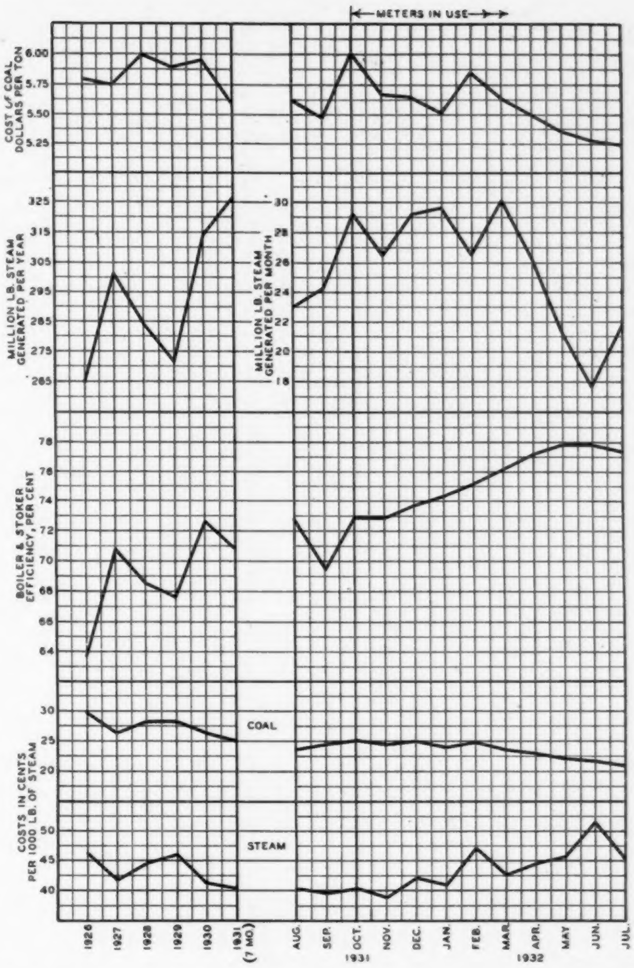


Fig. 1—Curves of fuel cost, steam production, efficiency and steam cost.

TABLE 3—BOILER PLANT OPERATING EXPENSES

Year		1926	1927	1928	1929	1930	1931
Cost of coal per ton, (dollars)		5.80	5.75	6.00	5.90	5.95	5.60
Tons of coal burned		13,242	13,664	13,249	12,897	13,998	14,520
Steam generated, lb.		264,918,000	301,222,000	283,926,000	271,574,500	314,028,200	326,332,300
Total cost of steam, (dollars)		122,180.53	125,257.21	126,760.66	124,131.62	129,086.68	131,094.61
Cost of 1000 lb. of steam, (cents)		46.2	41.7	44.7	45.8	41.2	40.2
	Salaries[1]	21.32	19.91	20.72	20.7	20.02	22.0
per cent of	Repairs & renewals	5.65	7.45	6.46	7.32	2.73	4.46
cost	Supplies & expense	0.25	1.25	1.77	3.89	5.87	4.64
of	Depreciation (entire plant)	6.05	5.78	5.30	4.45	4.20	3.74
1000 lb.	Telephone	0.03	0.03	0.03	0.03	0.03	0.03
steam	Insurance	0.45	0.26	0.37	0.32	0.25	0.22
	Water	1.95	2.32	2.45	1.96	2.50	2.69
	Fuel	64.50	63.00	62.90	61.33	64.40	62.22

Month and Year		Aug. 1931	Sept. 1931	Oct. 1931	Nov. 1931	Dec. 1931	Jan. 1932
Cost of coal per ton, (dollars)		5.63	5.48	6.00	5.67	5.65	5.52
Tons of coal burned		978	1,078	1,258	1,149	1,290	1,273
Steam generated, lb.		23,053,000	24,264,000	29,189,000	26,483,500	29,215,800	29,750,840
Boiler and stoker efficiency, per cent		72.07	69.5	72.91	72.86	73.72	74.38
Cost of 1000 lb. of steam, (cents)		40.42	39.61	40.23	38.83	42.3	41.0
Cost coal/1000 lb. steam (cents)		23.6	24.4	25.2	24.5	24.9	24.2
	Salaries	26.10	24.90	23.55	23.22	18.55	17.10
per cent of	Repairs & renewals	3.70	2.34	1.79	3.48	9.18[2]	10.58
cost	Supplies & expense	4.07	2.58	5.12	2.47	1.42	1.51
of	Depreciation (entire plant)	4.68	4.32	3.61	4.17	7.62	7.85
1000 lb.	Telephone	0.03	0.03	0.03	0.03	0.03	0.03
steam	Insurance	0.28	0.24	0.23	0.23	0.21	0.19
	Water	2.67	3.73	3.17	3.40	4.09	4.54
	Fuel	58.47	61.86	62.50	63.00	58.90	58.20

Month and Year		Feb. 1932	Mar. 1932	Apr. 1932	May 1932	June 1932	July 1932
Cost of coal per ton, (dollars)		5.85	5.64	5.50	5.36	5.28	5.24
Tons of coal burned		1,132	1,267	1,123	884	735	911
Steam generated, lb.		26,637,380	30,144,800	26,460,980	21,431,620	17,736,400	21,727,000
Boiler and stoker efficiency, per cent		75.2	76.15	77.24	77.84	77.83	77.37
Cost of 1000 lb. of steam, (cents)		47.0	43.0	44.7	45.7	51.5	45.3
Cost coal/1000 lb. steam (cents)		24.9	23.8	23.2	22.2	21.8	21.05
	Salaries	16.05	18.18	18.12	22.20	20.00	20.42
per cent of	Repairs & renewals	18.22	9.85	11.61	9.15	16.85	9.33
cost	Supplies & expense	1.09	1.48	2.42	1.67	1.68	1.62
of	Depreciation (entire plant)	7.47	10.23	11.11	13.12	14.36	13.00
1000 lb.	Telephone	0.03	0.03	0.03	0.03	0.03	0.03
steam	Insurance	0.19	0.19	0.20	0.25	0.27	0.79
	Water	3.94	4.78	4.47	5.32	4.48	6.11
	Fuel	53.01	55.26	52.04	48.26	42.33	48.70

[1] Labor costs are higher than they should be because of structural limitations of the plant which prevent the use of an efficient method for handling coal and ashes.

[2] At this time the gradual replacement of parts of the old equipment, subject to wear, was begun and continued over an extended period which accounts for the increase of the "repairs and renewals" item in this and succeeding months.

son of this test data with normal operating efficiencies (Table 3) shows that this was *not* a boiler doctored up for the occasion. The boiler was selected at random to run the test as a further check on our records. The only consideration in its selection was its location, which aided in the isolation of the weighed coal.

An interesting point brought out by the data of Table 3 and the curves, Fig. 1, is the effect of decrease in

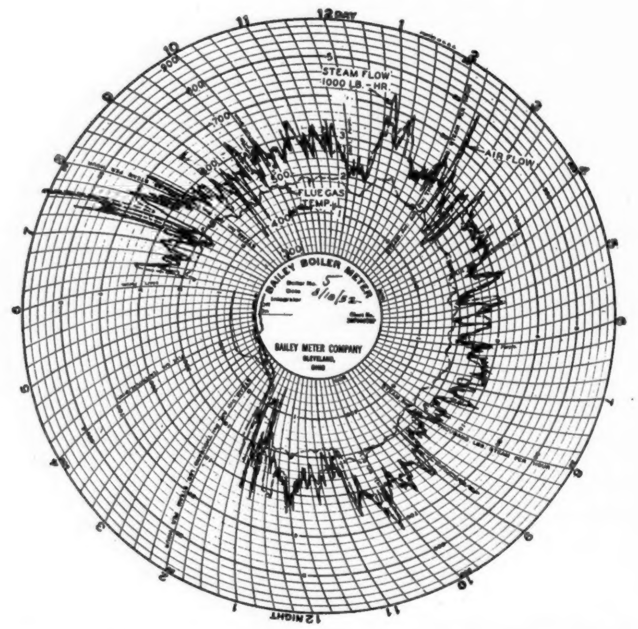


Fig. 2—Boiler meter chart showing steam flow (solid), air flow (dash) and flue gas temperature (dot and dash).

quantity of steam generated on its cost per 1000 lb. This is most noticeable in the June figures which show an increased cost per 1000 lb. of steam at a time when the cost of coal was decreasing and efficiency increasing. The reason for this is that the unchanging amount of fixed charges had to be carried by the lesser quantity of steam. Extensive repair and renewal work carried on at the time also contributed to higher steam cost.

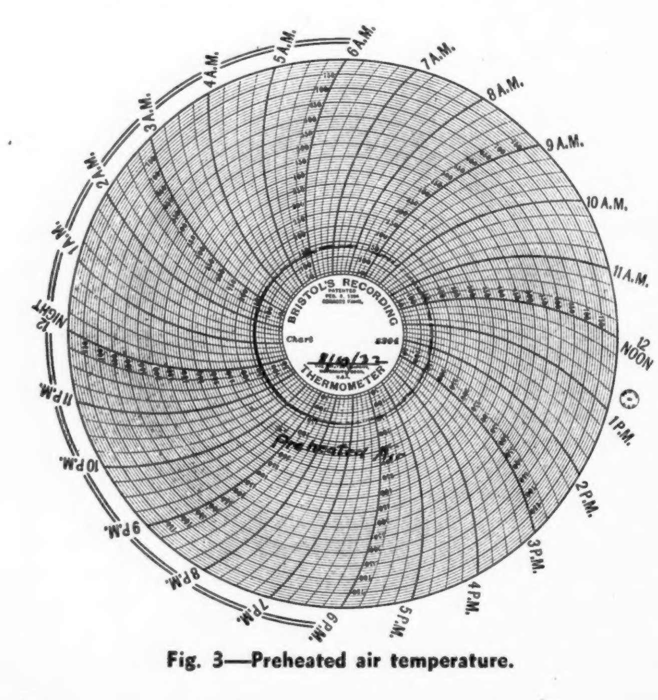


Fig. 3—Preheated air temperature.

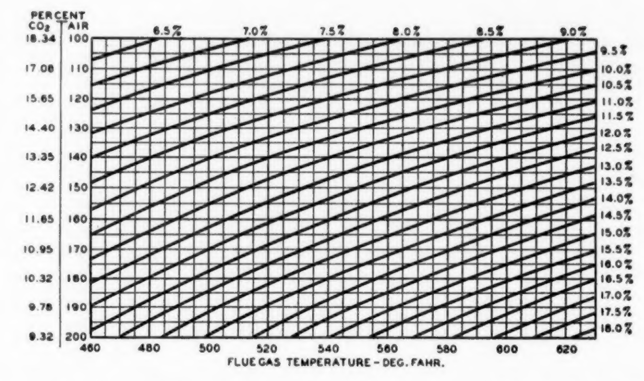


Fig. 4—Percentages of available heat in the coal lost in the flue gases at different flue gas temperatures and different quantities of air.

Further fuel economy could be obtained were it not for the fact that structural conditions limit the furnace volume to 308 cu. ft. As a consequence the coal used must have a low volatile content; this requisite prevents the purchase of cheaper coal which otherwise could be used satisfactorily. The limited combustion space would also be a handicap if increased boiler ratings were required.

Table 4, presents data of a test made to determine the minimum excess air and shows the advantage gained by the use of the air preheater. The gross combined efficiency having increased from 70 to 77 per cent, we next determined to demonstrate how much we could credit to the use of boiler meters and how much to the air preheater, so we closed off the preheater for the month of December, 1932, and the efficiency dropped to 73 per cent for that month.

TABLE 4—DATA OF TEST MADE TO DETERMINE MINIMUM AMOUNTS OF EXCESS AIR AT VARIOUS RATINGS

BOILER NO. 1, SEPT. 14, 1932

	Steam[1] Flow	Air[2] Flow	Flue Gas Temperature	Steam Pressure	Water Column	CO_2	CO_2 O_2	CO_2 O_2 CO	N_2	Total Air
	22.0	19.0	530	155	75%	15.8	18.4	18.4	81.6	113.8
	17.0	16.0	520	154	75	16.0	18.2	18.2	81.8	111.4
	19.0	17.0	510	156	75	16.0	18.4	18.4	81.6	112.5
	17.0	16.0	500	155	50	15.0	18.0	18.0	82.0	116.0
	18.5	16.5	515	155	50	16.2	18.2	18.2	81.8	110.2
	21.0	18.0	540	154	75	16.8	18.2	18.2	81.8	107.0
	17.5	15.5	510	153	75	16.8	18.4	18.4	81.6	108.2
	22.0	18.5	530	155	50	15.4	18.2	18.2	81.8	114.8
	16.0	15.5	520	156	75	16.0	18.6	18.6	81.4	113.8
	16.5	15.5	500	155	75	16.2	19.0	19.0	81.0	115.0
Avg's. ...	18.65	16.75	517	155	68	16.0	18.4	18.4	81.6	112.6

[1] Steam flow in thousands of pounds per hr.
[2] Position of air flow pen on scale of steam flow.

There is no occasion for further detailed discussion of performance since the accompanying charts and tables tell the story completely.

Fig. 1 shows curves for the values given in Table 3. Figs. 2 and 3 are typical performance charts. Fig. 4 gives curves of available heat in the coal lost in the flue gas at different temperatures of the gas and different quantities of air based on a thermal value of the coal of 13,800 B.t.u. A copy of this chart is posted in the boiler plant locker room and has created considerable interest among the members of the organization. It has helped the operators to acquire a better understanding of what they are trying to do and has thus caused them to take more interest in doing it.

Schmidt High-Pressure Boilers

By JAMES CUNNINGHAM

The Schmidt Boiler is one of several interesting designs for generating steam at high pressures which have been developed in Europe since the beginning of this century. A distinctive feature of this design is that it has two separate water systems, the primary system being a closed circuit containing pure distilled water which, when evaporated, serves as the heating medium for generating steam in the secondary system. The author reviews the design and development of this boiler, describes several installations, and discusses operating experiences and performance . . . Other high-pressure boiler designs described in recent issues of COMBUSTION are those of the Loeffler Boiler and the Benson Boiler.

THE name of the late Dr. Wilhelm Schmidt is well known to engineers in connection with the production and use of superheated steam, but it will no doubt occasion some surprise to many to learn that as long ago as 1888 he constructed and tested a boiler and engine at a pressure of 1425 lb. per sq. in. The development of the design of boiler bearing his name may, however, be regarded as dating from the construction in 1910 of a vertical-tube boiler for a working pressure of 853 lb. per sq. in. This was followed by a number of trial plants until in 1923 the system of indirect heating which is characteristic of the Schmidt boiler was introduced.

The Schmidt boiler has two separate water systems. The primary system consists of a closed circuit containing pure distilled water. This is evaporated in the usual manner in tubes exposed to the radiant heat of the furnace and in contact with the products of combustion, but is condensed in a coil or coils located in the main boiler drum, then returning to the heating tubes to be re-evaporated. It thus serves merely as an agent for transferring heat to the feed proper contained in the main drum, the latter not being subjected to direct heat.

Two general designs have been adopted for the construction of the primary system, shown diagrammatically in Figs. 1 and 2. The first of these Fig. 1, adopted for locomotives and marine boilers, has two duplicate sets of evaporating tubes, etc., arranged symmetrically on both sides of the firebox. Equalizing pipes are provided as indicated between the two sets for water and steam. In the case of locomotives the products of combustion pass forward through a low-pressure boiler or the economizer and superheater. The other design Fig. 2, used for stationary land boilers, has only one set of evaporating tubes, connected outside the setting to the bottom water drum and to the intermediate separating drum. The heating tubes may either be arranged in coils as shown in the illustration or can, in addition, be arranged vertically around the combustion chamber. The pressure in the primary system is from 280 to 715 lb. per sq. in. higher than the working boiler pressure, and adjusts itself automatically to the changing conditions in operation. It is in the first place dependent on the rate of firing and on the surface of the heating elements (condensing coils) in the main drum.

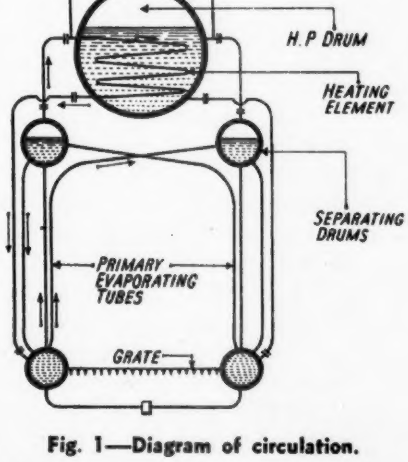


Fig. 1—Diagram of circulation.

It will be noted that in both cases an intermediate drum is provided to receive the mixture of steam and water from the evaporating or heating tubes; steam alone passes into the coils in the main drum, the condensate returning by suitable down tubes to the water drum, where it rejoins the water separated in the intermediate drum. In the early experiments this separator was not employed, resulting in a low rate of heat transmission through the heating elements, *i.e.*, only some 205 B.t.u. per sq. ft. per hr. per deg. fahr. The adoption of it greatly improved the heat transmission, up to 615 B.t.u. per sq. ft. per hr. per deg. fahr., and also considerably increased the circulation of water through the evaporating tubes. The rate of heat transmission

* Reprinted from *The Power Engineer*, London, December, 1932 issue.

can be still further improved, values of 740 B.t.u. having been reached in individual cases.

The use of pure distillate in the primary system, freed from air when put into service, insures that the tubes remain free from scale and from corrosion due to oxygen. In consequence they can be made of smaller bore than in other types of boiler, with resultant benefit in regard to the stresses in the material. Further, the lengths of the tubes can be much greater than is possible in vertical-tube boilers, being made up to 92 ft., reducing the number of ends to be expanded into the drums. The definite circulation, always proceeding in the same direction, further prevents the occurrence of stagnant points at which decomposition of steam could take place, with resultant corrosion. Since it is not subjected to direct heat the actual feedwater supplied to the main drum requires only chemical treatment, and in fact boilers have been operated for short periods with untreated water. Deposits on the heating elements in this drum only cause an increase in the pressure in the primary circuit, and can be removed by chemical means.

One of the first applications of the indirect system of evaporation was to the high-pressure locomotive designed in 1924 for the German State Railways. After thorough tests during 1926 to 1929 this locomotive was put into regular express service in 1930. Four further locomotives have since been fitted with the Schmidt high-pressure boiler, including one for the London Midland & Scottish Railway Co.

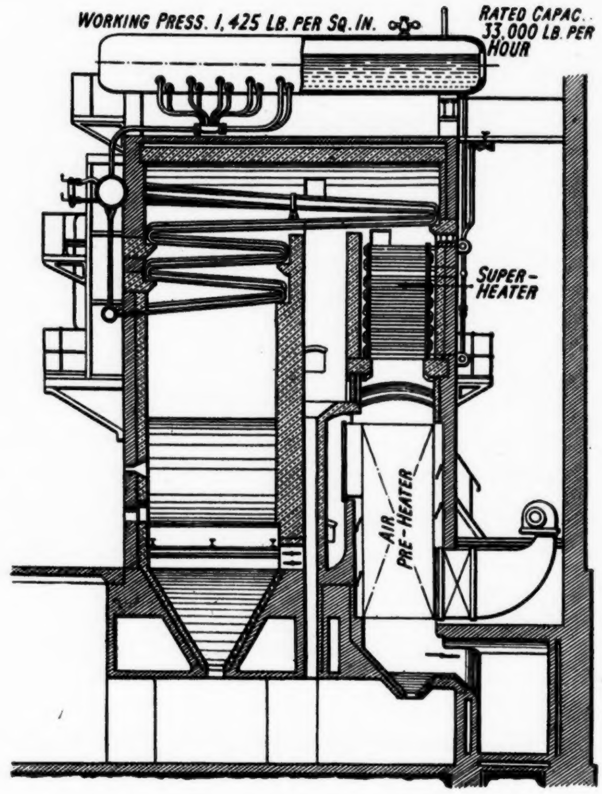


Fig. 3—Schmidt boiler at Bitterfeld.

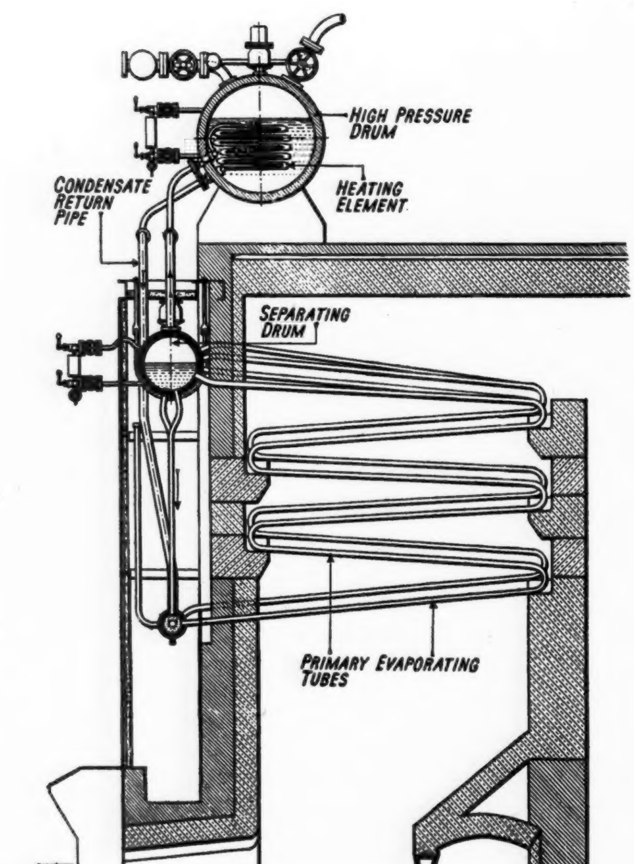


Fig. 2—Diagrammatic section of Schmidt high-pressure boiler.

The first stationary land boiler of this system was the experimental one for a working pressure of 853 lb. per sq. in. started up in February, 1926, at Wernigerode. In the autumn of 1927 it was subjected to very thorough tests on behalf of the I. G. Farbenindustrie, including a four weeks' continuous run. During the first 14 days the feedwater was treated by the lime-soda process, the residual hardness being about 12 deg., while for the last fortnight untreated water was used with from 35 deg. to 52 deg. hardness. During each of these periods the boiler was not blown down, resulting in very heavy deposits in the drum, especially after the second period with untreated water. The contents of the drum, from which high-pressure steam was produced, were described as being like thick pea soup. As the result of these tests the I. G. Farbenindustrie ordered a boiler for a working pressure of 1425 lb. per sq. in. for their Bitterfeld works, and another for a pressure of 925 lb. per sq. in. for their Dormagen works, followed later by a further boiler for the same pressure for the latter works.

The Bitterfeld boiler, Fig. 3, was put into commission in October, 1928, being rated at 33,000 lb. per hr., superheated to 800 deg. fahr. from feed at 390 deg. fahr. It was actually mainly worked at an evaporation of 37,400 to 39,700 lb. per hr., being on one occasion overloaded to 46,300 lb. per hr., which maximum output could have been carried continuously had it been possible to fire at a corresponding rate. The boiler is fitted with mechanical trough grates, and has an air heater but no economizer.

A number of troubles were experienced in the early

stages of operation which were very carefully investigated and yielded valuable information. The vital point is, of course, the circulation in the primary system, since on this depends the adequate cooling of the tubes exposed to the heat of combustion. While the statements already made on this point are fully substantiated by subsequent experience, several failures occurred in the circulation in the early days, the causes of which lay, however, in defects in manufacture or in the method of operation. Thus, examination of the intermediate drum after the failure of a tube showed that it contained considerable quantities of scale and material from welds. Further inspection revealed that nearly all the primary tubes were more or less choked. These long tubes were made by butt welding shorter lengths together, and the material which had accumulated on the inside of the tubes at the welds had not been properly removed. In some cases dislodged material had been trapped at such restricted points, blocking the tube and so stopping circulation, with consequent overheating.

It was also found that the flow of water through the tubes was not steady but pulsating, the number of pulsations per minute depending on the level of the water in the intermediate drum. If this fell, due to loss of water by reason of a leaky tube or leaky fittings, the pulsations became slower, ultimately reaching a point at which the bubbles of steam became stagnant, followed by decomposition of the steam and corrosion of the tube. Recent tests on the Bitterfeld boiler as now operated are stated to have shown that the circulation is steady and free from pulsations at the entrance to the rising tubes, the velocity there being 118 to 158 ft. per min. Details of these tests, made by the I. G. Farbenindustrie, have not yet been made public. The reduction of the quantity of water in the primary system converts the upper portion of the evaporating coils into superheater tubes, and Herr Hartmann in a lecture last year stated that tube corrosion immediately disappeared as soon as care was taken to prevent such superheating. The amount of water in the primary system is shown by a water-level gage, or by a special combined dial gage with two pointers, one for pressure and the other for temperature, superheating being indicated if the latter is in advance of that for the pressure, in which case pure water should be fed into the system.

While it is desirable to take immediate steps to correct superheating when it occurs, the matter is not one of extreme urgency, as shown by the experience with another Schmidt boiler, at Dormagen in 1929. Here, owing to a leaky suction valve, the feed pump for the

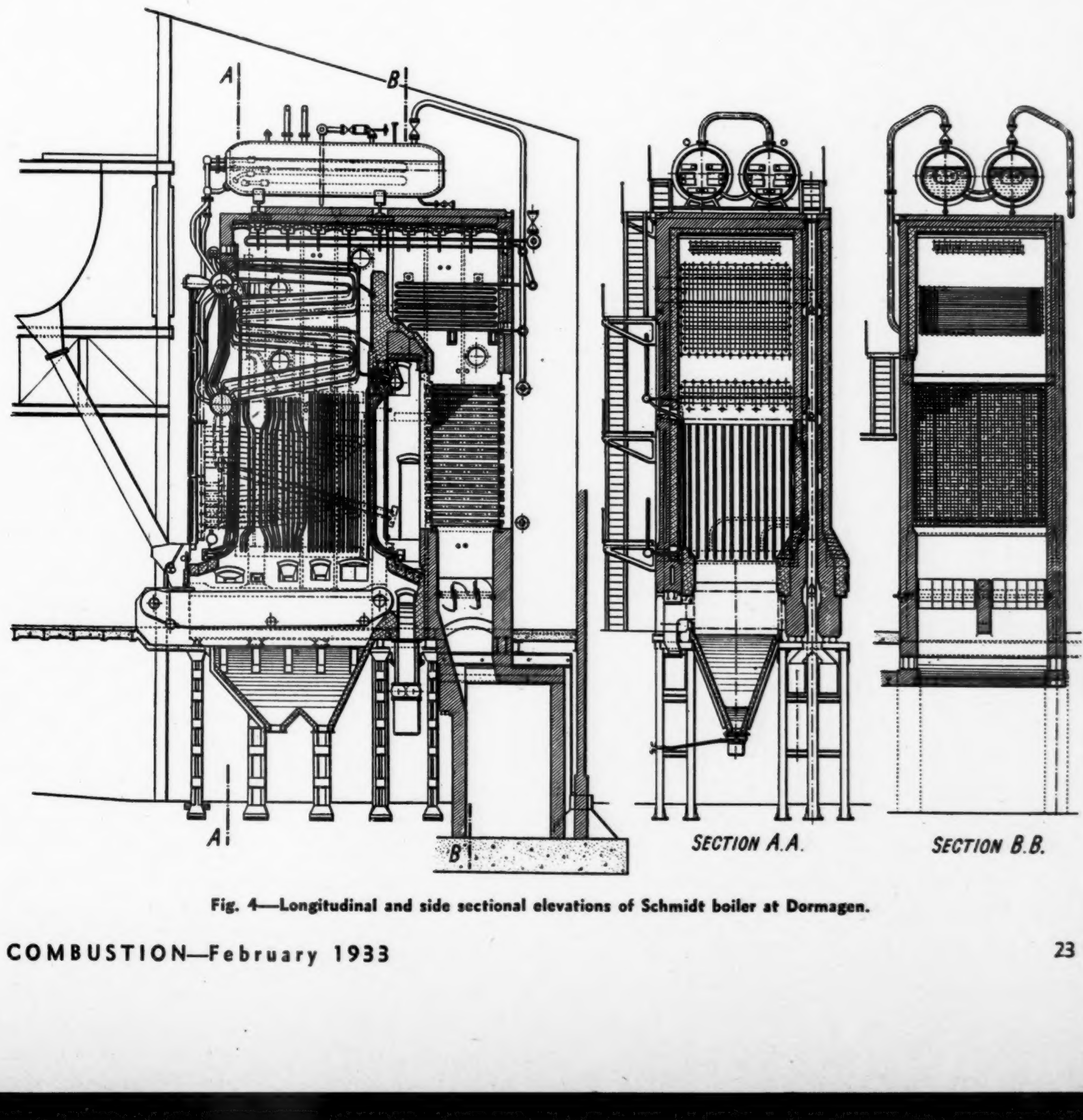


Fig. 4—Longitudinal and side sectional elevations of Schmidt boiler at Dormagen.

primary system failed to act when required. Instead of shutting down the boiler it was kept at full load until a tube failed, fully four hours after the steam temperature began to rise above that corresponding to saturation at the primary pressure.

The difficulties at Bitterfeld were further accentuated by the use of water which had not been de-aerated, in making up the leakage, leading to corrosion of the evaporating tubes. The quantity of make-up amounted to the full content of the primary system every day for months, due to leaky fittings—safety, feed and air valves —which was only overcome by replacing these with new ones. During this time the steam in the primary system was superheated some 108 to 180 deg. fahr., cold distilled water being pumped into the intermediate drum every 5 to 6 hr. In addition the feedwater, instead of being at 390 deg. fahr. was only heated from 104 deg. to 140 deg fahr. which was equivalent to a constant overload of some 25 to 30 per cent. The cold water, initially not de-aerated and simply fed into the front end of the main drum, gave rise to corrosion of the outside of the heating element at this point. This corrosion was overcome by partial de-aeration of the feedwater and the fitting of distribution plates, within the main drum, on which the water was raised nearly to the evaporating point.

Yet another source of trouble at Bitterfeld arose from the high temperature of the preheated air, up to 570 deg. fahr. which was initially employed to insure combustion of the fine raw lignite coal with high moisture content. Owing to the resultant high combustion temperature combined with the high speed of flow of the gases, the lower portions of the evaporating coils became heavily covered with slag, leaving only narrow passages for the products of combustion. The consequent reduction in the amount of heat absorbed by radiation, along with the overload due to the cold feed mentioned above, raised the temperature of the products of combustion throughout the boiler and superheater, the temperature of the superheated steam being 986 deg. fahr. instead of 800 deg. fahr. as specified. This led to the failure

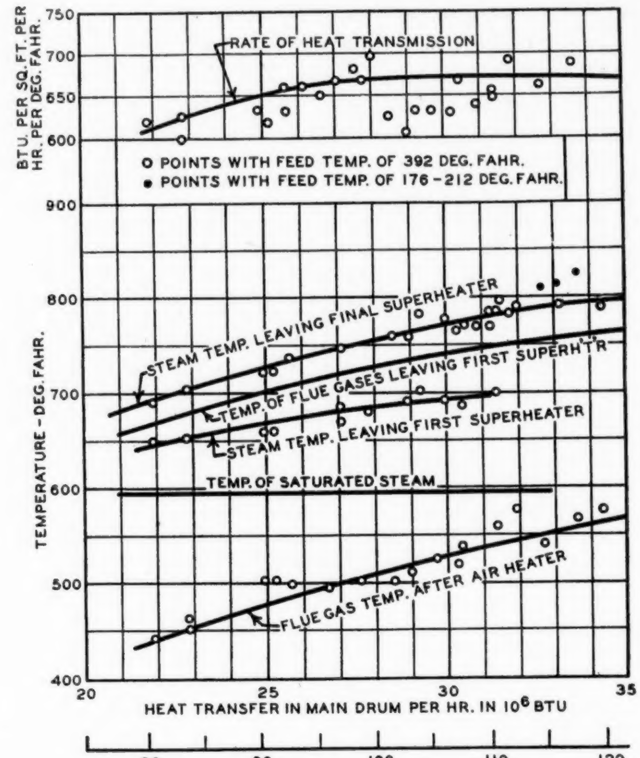


Fig. 6—Test results on Bitterfeld boiler in normal operation.

of some of the superheater tubes made of ordinary carbon-steel, examination of the tubes further revealing the same internal choking with material from the welds already referred to in connection with the tubes of the primary system. The superheater was reconstructed, and, at the desire of the I. G. Farbenindustrie, divided into two sections, arranged so that they could be connected in parallel or in series. The upper, smaller, portion of the superheater, located in the zone of highest temperature, was fitted with tubes of a number of special steels for comparative trials. The feed temperature was, however, at the same time increased from 366 deg. to 390 deg. fahr. and the air temperature reduced to 300 deg. fahr. so that the steam temperature is now only 800 deg. fahr., it being only possible to reach 930 deg. fahr. on a temporary extreme overload. Tests have been made in which the steam temperature leaving the superheater averaged between 880 deg. and 970 deg. fahr., and no difficulties have arisen so far.

The Bitterfeld boiler has been in operation for 11,400 hr., including 1200 hr. with steam temperatures of 930 deg. fahr., and 2000 hr. with chemically treated feedwater. The addition of phosphate to the feedwater prevented the formation of scale to the extent that the boiler could be operated continuously at full load.

The first boiler at Dormagen was put into commission at almost the same time as that at Bitterfeld. The rated capacity is 55,000 lb. per hr., but peak outputs of 79,000 lb. per hr. have been obtained with clean heating surfaces. In this boiler the length of the evaporating tubes of the primary system was reduced to 52 ft. 6 in. On test the boiler gave an efficiency of 85 per cent. The second boiler at Dormagen, Fig. 4, has a rated capacity of 66,000 lb. per hr., although it occupies only half the ground area of the first one. The arrangement of the heating elements in the main drum differs from that of

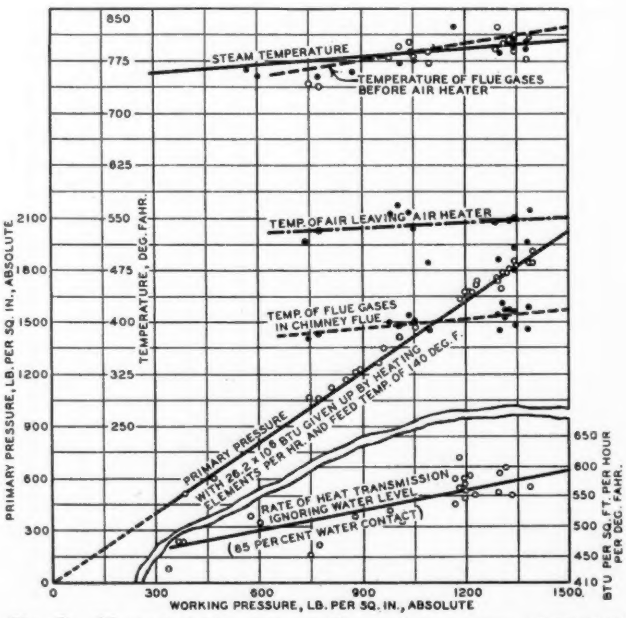


Fig. 5—Characteristic curves with varying pressure, Bitterfeld boiler.

the other boilers. In that at Bitterfeld the coils are arranged transversely to the drum, the connections being made through the side of the latter. The first Dormagen boiler had longitudinal coils, these being attached to large covers on the ends of the drum. Trouble was experienced at first in making these covers tight, and in the second boiler, although the coils are still longitudinal, the connections pass through the ends of the drum itself, only manholes being provided for access to the interior.

In recent designs of Schmidt boilers which are to be fed with chemically treated feedwater, the main evaporating drums are each fitted with a single longitudinal heating element so arranged that the elements can be exchanged for clean ones after cooling. Such changing can be effected in at most two days from shutting down the boiler to heating up again. By this means absolutely reliable operation is insured, even if care be not exercised in the control of the feedwater.

A valuable feature of the Schmidt boiler is that it can be operated at full steam output at all pressures between 285 and 1425 lb. per sq. in., without priming at the lower pressures. In illustration of this, Fig. 5 gives the test results for the Bitterfeld boiler at pressures from 370 to 1425 lb. per sq. in. abs. It will be seen that the steam, air and flue gas temperatures increase uniformly with the working pressure, as does also the primary pressure. A number of other curves giving the results of tests on this boiler in normal condition at various load factors are given in Fig. 6. The tests in question were made after replacement of one-half of the evaporating tubes, which had become scaled through incorrect operation, by new tubes of more technically correct form.

In conclusion the writer would thank the Schmidt'sche Heissdampf Ges.m.b.H., of Kassel, and the Superheater Company, of London, to whom he is indebted for information regarding the above boilers.

American Standards Association Approves New Standard for Steel Flanged Fittings

A new American Standard for steel flanged fittings and companion flanges, replacing a former American Tentative Standard, has been approved by the American Standards Association. Pressure ratings of 300 and 1500 lb. per sq. in., respectively, replace in the new standard the old tentative standard ratings of 250 and 1300 lb. per sq. in. The new standard covers the same flanged fittings as the old with the addition of fittings for a maximum steam service pressure of 150 lb. per sq. in. at 500 deg. fahr. (or 100 lb. per sq. in. at 750 deg. fahr.) and flanged base-fittings for pressures of 300, 400, 600, and 900 lb. per sq. in. Companion flanges are given for the pressure ratings of 150, 300, 400, 600, 900, and 1500 lb. per sq. in. The 3½ in. flanged fittings in the 900 and 1500 lb. series have been eliminated. The revision of the old standard has resulted in changes of certain dimensions, such as the minimum metal thickness of some fittings, which was increased on account of the increase in two pressure ratings.

The revised standard was developed by Subcommittee 3 on Steel Flanges and Flanged Fittings, of the Sectional Committe on Pipe Flanges and Fittings (B16). The chairman of the sectional committee, and also of subcommittee 3, is Collins P. Bliss, Dean, Engineering School, New York University. The work on this project is jointly sponsored by the American Society of Mechanical Engineers, the Manufacturers Standardization Society of the Valve and Fittings Industry, and the Heating and Piping Contractors National Association.

Copies of the new standard are available from the American Standards Association, 29 West 39th Street, New York, at 65 cents each.

The Turbine Sales Department of the General Electric Company has been consolidated with the Central Station Department of the company, as a division of that department, it has been announced by Vice-President J. G. Barry, following the announcement of the retirement of Elmer E. Gilbert, Manager of the Turbine Sales Department. R. B. Beale, former Assistant Manager of the Turbine Sales Department, succeeds Mr. Gilbert with the title of Manager of the Turbine Division.

Mr. Beale, a native of Washington, D. C., was graduated from Maryland State College in 1896 with the degree of bachelor of science, and from Johns Hopkins University in 1899 with the degree of electrical engineer. He entered the Testing Department of the General Electrical Company in 1899, and in 1901 entered the Direct-Current Engineering Department. In 1902 he was transferred to the Lighting Commercial Department, now the Central Station Department. He was transferred to the Turbine Department in 1907, and in 1922 was appointed Assistant Sales Manager of the Department.

The Bernitz Furnace Appliance Company, Boston, have recently appointed new agents in Cincinnati and Cleveland, Ohio, as follows:

The McLean, Patterson Company, Cincinnati, for the territory comprising southwestern Ohio, including Dayton, Springfield and Columbus.

The Reese-Wilson Engineering Sales Company, Cleveland, for northeastern Ohio.

Correction

In the article "Burning Pulverized Petroleum Coke Breeze" by E. J. McDonald, published in January, 1933, COMBUSTION, the title under the view of the boiler room of the Northeast Station of the Kansas City Power & Light Company (Page 5) inadvertently stated that chain grate and multiple retort underfeed stokers, as well as pulverized fuel equipment, are used in this plant. The reference to multiple retort underfeed stockers was incorrect. The firing equipment includes both natural and forced draft chain grate stokers and pulverized fuel systems.

Patents*

By GEORGE RAMSEY
NEW YORK
Patent Lawyer
Member A. S. M. E.

In this article Mr. Ramsey has concluded all of the steps necessary for obtaining a patent, and has referred to Petitions, Appeals, and legal remedies available to an applicant where his patent has been refused upon what he believes to be a meritorious invention. The present article also discusses and analyzes the nature of a United States patent.

PART VII

Petitions to the Commissioner

The ordinary procedure of prosecuting an application for patent does not go outside of the Examining Corps, but occasionally issues arise between an applicant and the Examiner that require attention of higher authorities.

All matters relating to the merits of an application such as patentability of a claim, requirements of division, questions as to new matter introduced by amendments, sufficiency of a reference and the like are all appealable issues.

All other questions, especially questions of procedure, arising between an applicant and the Patent Office may be reviewed by the Commissioner on petition. The work of considering petitions is usually delegated to the First Assistant Commissioner, except as to serious matters, such as any charge of irregularity in handling a case, which are usually considered by the Commissioner in person. Fees are charged for appeals but no fee is charged for a petition, except that fees are now charged for a petition to revive an abandoned application.

The petition must be in writing and must clearly identify the application on which it is based. Where the grounds for the petition are not of record in the Patent Office the petition must be accompanied by an affidavit setting forth the facts on which the petition is based.

Issues reviewable by petition are of many forms and varieties but to give some idea of the character of these matters a few instances will be cited. Where an Examiner has been arbitrary and vacillating in his rulings and rejections, redress may be had by way of petition. If an amendment has been filed and the Examiner holds the amendment to be insufficient and that the application is abandoned, petition may be filed. Where the Examiner refuses to enter what the applicant believes to be a proper amendment a petition may also be filed. The authority to inspect an abandoned file can only be obtained by a petition, usually based on a partial assignment or a Court order. Where an applicant has threatened a competitor that he is infringing claims of a pending application and persists in his threats, the Commissioner, on petition, may permit the competitor to inspect the pending file.

On one occasion the Patent Office refused to accept drawings where shading was shown by stippling. The Chief Draftsman ruled that shading should be shown by lines. This rule arose very early in the history of the Patent Office for the reason that reproductions of the drawings were then made by wood cuts and it was difficult to reproduce stippling by wood cuts whereas lines could be easily shown thereby. The reason for the rule disappeared when photo-engraving came in as a method of reproducing drawings. The Chief Draftsman, however, like most Government Officials, insisted on applying the old rule. An application was filed with stippled drawings which were held to be informal and a petition was presented to the Commissioner pointing out the reasons why the rule should not apply today. This petition was granted and the Patent Office today will accept properly made stippled drawings to show frosted or shaded surfaces.

Mandamus

There is no statutory provision for an appeal from a decision based on a petition to the Commissioner. The Patent Office is now under the Department of Commerce, and in the past, attempts have been made to appeal to the head of the Department of which the Patent Office is a bureau. During the time when the Patent Office was under the Interior Department, several such attempts were made. These attempts were usually referred to the Attorney General for the United States, and the rulings have been uniform to the effect that the Secretary of the Department would not consider appeals from the Patent Office even though the statutes do provide that the Rules of the Patent Office shall be adopted and approved by the Secretary of Interior. (The Secretary of Commerce is now substituted for the Secretary of the Interior.) The basis of this ruling is that purely discretionary matters are within the jurisdiction of the Commissioner, and as to matters pertaining to the merits of a case, in other words, judicial in character, appeals to the Courts are provided for by the law.

In cases where the laws provide that the Commissioner must act and the Commissioner refuses to act, then the petitioner's redress is in the form of a mandamus filed in the Courts against the Commissioner. Mandamus is a common law writ and is of the type of an extraordinary remedy in cases where ordinary methods of proceeding are inadequate to provide remedies for the parties injured. This writ is available only where to refuse a remedy would be to refuse justice. In order that the remedy of mandamus will apply, the official to whom it is directed, must be required by law to perform some specific act and must have refused to carry out the duties of his office as prescribed by law. Mandamus will not apply to judicial opinions. Therefore the Commissioner cannot be mandamused relative to any matter upon which the law gives him discretionary powers. The Courts will only compel the Commissioner to act where he has no discretion and where the law requires that he shall act. For example, if a petitioner believes he has a right to inspect an application and inspection is refused by the Commissioner, he may file a mandamus against the Commissioner. The Courts are very loath to grant a mandamus against the Commissioner but a Court has ruled that the Commissioner may be mandamused to obtain copies of an abandoned application which he refused and which were material to the matter before the Court in a patent suit. If the Commissioner refuses to allow an appeal and it is clearly and affirmatively shown that the applicant has a right to an appeal and that such right has been denied, the petitioner may resort to mandamus to compel the appeal to be allowed. Where the Commissioner of Patents refused to direct the Primary Examiner to forward to the Examiners-in-Chief an appeal from a ruling requiring claims of a case to be divided, mandamus was granted against the Commissioner to compel the appeal. Mandamus will not be granted to compel the Commissioner to revive an abandoned application. The law specifically makes this an act of discretion.

Final rejections are discretionary and of a judicial nature and mandamus will not be granted to compel the Commissioner to withdraw a final rejection.

Mandamus is an extraordinary remedy and very seldom succeeds. The Courts are powerless to direct the action of a Governmental Official unless a positive, definite, legal right set forth by statute has been violated by the officer.

Ex Parte Appeals to the Board of Appeals

Where the claims of an application have been twice and finally rejected for the same reasons upon grounds involving the merits of the invention, such as lack of invention, novelty, utility, abandonment, public use or sale, inoperativeness of the invention, aggregation of elements, incomplete combinations of elements, new matter, or upon twice being required to divide the application, the applicant has a right under the law to appeal from the decision of the Primary Examiner to the Board of Appeals upon the payment of the prescribed appeal fee which is now $15.00. Such an appeal is known as an *ex parte* appeal since there is no opponent. The appeal must be in writing and state the points upon which the appeal is taken. When the *ex parte* appeal is filed, it is referred to the Primary Examiner, who, if it is in regular form and relates to an appealable action, shall within ten days from the filing of the appeal furnish the Board of Appeals with a written statement of the grounds of his rejection and all the points involved in the appeal. A copy of this statement must be furnished the attorney.

The attorney then uses this statement of the Examiner as a basis upon which to write a brief, analyzing the references relative to the claims and pointing out why the appealed claims are patentable over the references and reasons for the final rejection, as set forth by the Examiner. The appeal may be heard on oral argument providing a request for oral argument is made at the time when the appeal is filed. No amendments, affidavits, or other matter affecting the appeal should be filed after the appeal is taken. Occasionally, affidavits are filed, though this is not good practice, and when such affidavits are submitted after appeal, the Board of Appeals may or may not, at its discretion, remand the case to the Primary Examiner for further consideration in view of such affidavits. All matters of the case, however, should be finally concluded and of record before the case is appealed.

In the past, appeals could be taken from the decision of the Board of Appeals directly to the Commissioner himself, but this seemed an anomaly because the Board of Appeals was constituted by three men and it did not seem reasonable to appeal from the judgment of three men to the judgment of one man. Furthermore, the duties of the Commissioner of Patents are heavy in the administrative work of his office and it was deemed desirable to relieve the Commissioner of this burden.

The present Board of Appeals, therefore in accordance with the present laws, comprises nine Examiners-in-Chief and three Assistant Commissioners. Appeals are heard by a tribunal of three comprising in each case an Assistant Commissioner of Patents and two members of the Board of Appeals. The reason the Assistant Commissioner of Patents sits at hearings as a member of the Board is in order that the decision of the Board of Appeals shall be in effect a decision approved by the Commissioner.

The procedure before the Board of Appeals is similar to a Court procedure. Each hearing is conducted privately in view of the fact that applications for patents are retained in secrecy. Thirty minutes are permitted for oral argument. The Examiner is not represented at the argument. Models may be used or any other material adapted to demonstrate the operation of the device and its novelty over the art cited. When the hearing is concluded, a member of the Board is designated to write the decision and the other members confer with him on the questions raised.

The Board of Appeals renders a written decision and may either affirm or reverse the decision of the Primary Examiner on the points on which the appeal has been taken. Should the Board discover any new grounds not involved in the appeal for granting or refusing the Letters Patent in the form claimed, it shall include in its decision a statement to that effect together with its reasons for the finding. The ruling of the Board of Appeals is binding upon the Primary Examiner. If the Board of Appeals finds the claims appealed are allowable, the Examiner must allow the case.

If the decision of the Board of Appeals includes a statement that a patent may be granted if the claims are amended, the applicant has the right to amend in conformity with the statement, and the decision of the Board is binding upon the Primary Examiner in the absence of new references or new grounds of rejections as to the amended claims.

A case which has been appealed shall not be reopened by the Primary Examiner without written authority from the Commissioner and then only for consideration of matters not already adjudicated.

Ex Parte Appeals to the Court of Customs and Patent Appeals

The decision of the Board of Appeals closes the case so far as the Patent Office is concerned. However, where the Board of Appeals has decided adversely against the applicant and the applicant is still convinced that his claims define a patentable invention over the art cited, he has two courses which may be pursued and he must make a choice as to which of these courses he desires to follow. He may appeal to the Court of Customs and Patent Appeals or he may file, in a United States District Court, a Bill in Equity directed against the Commissioner of Patents. He can not do both. This Court of Customs and Patent Appeals is located in Washington and comprises a presiding Judge and four Associate Judges appointed by the President with the advice and consent of the Senate. Any three members of the Court constitute a quorum but it requires concurrence of three members for any decision.

Where an appeal is taken to the United States Court of Customs and Patent Appeals, the applicant must give notice to the Commissioner and file in the Patent Office within forty days, exclusive of Sundays and holidays, from the decision of the Board of Appeals, his reasons in writing for the appeal. Having taken this appeal to the Court of Customs and Patent Appeals, he waives his right to file a Bill in Equity in the United States District Court.

In filing this appeal to the Court of Customs and Patent Appeals, the applicant must file a Petition addressed to the Court in which he shall briefly set forth that he has notified the Commissioner of the Appeal and that he lays before the Court certified copies of the original papers as evidence in the case. This Petition for Appeal and certified copy of the record shall be filed within forty days exclusive of Sundays and holidays from the date when the reasons for appeal were filed with the Commissioner of Patents; however, the Commissioner may in special cases and for sufficient cause extend the time beyond the forty days.

The transcript of record is made up in the Patent Office. In making up the transcript of record on appeal, it shall be the duty of the Commissioner of Patents to submit only the necessary papers showing the complete history of the case but to omit all papers not pertinent to the history, such as notice of hearings, receipt of fees, etc.

This record must be printed under the supervision of the Clerk of the Court and the printing costs together with the Clerk's fee for supervising the printing must be paid to the Court by the applicant, otherwise the case will not be docketed.

After the record has been duly filed and all the Court requirements complied with, fifteen copies of a printed brief must be filed within forty days after the record has been printed and three copies must be deposited in the Patent Office.

When the case comes up to be heard, thirty minutes are allowed for argument. The Commissioner of Patents is represented at this argument by the Solicitor for the Patent Office who is the head of the Legal Department for the Patent Office. The attorney for the applicant will present arguments in favor of allowance of the claims, and the Solicitor for the Patent Office will present the Patent Office side of the case and argue in favor of the decision of the Board of Appeals. The decisions of the Court of Customs and Patent Appeals are confined solely to points set forth in the reasons for the appeal.

The decision of the Court of Customs and Patent Appeals is entered in the record of the case in the Patent Office and is binding on the Commissioner. If the Court of Customs and Patent Appeals reverses the Commissioner of Patents and holds the claims are allowable, then the case will be passed to issue.

Bill in Equity

The applicant may choose the second course, namely, filing a Bill in Equity in the District Court providing he has not filed an appeal to the United States Court of Customs and Patent Appeals. In this case, the Bill of Complaint is served directly on the Commissioner, but the Commissioner can only be served in the jurisdiction of his Official residence which is the District of Columbia. In a few cases, the Commissioner has consented to be served outside of his jurisdiction. This Bill in Equity is addressed to the Commissioner in his official capacity and not as a private individual. The Bill in Equity procedure is really a trial and the applicant may introduce testimony of experts and introduce exhibits to show that his invention is patentable over the references cited by the Patent Office. This procedure follows the Court procedure of the particular United States Court which has jurisdiction of the case. Certified copies of the record in the Patent Office are submitted to the Court and the trial proceeds in the usual order. The Commissioner of Patents is represented by the Solicitor for the Patent Office. All expenses of the proceedings must be paid by the applicant whether the final decision is in his favor or not. The law provides that after adjudication by the District Court, that if the decision is in the favor of the applicant for a right to a patent, the Court shall authorize the Commissioner of Patents to issue such patent on the applicant filing in the Patent Office a certified copy of the Court's decision and otherwise complying with the requirements of the law.

The Nature of United States Patents

We have now traced the several *ex parte* steps necessary to get a patent. We have not gone into interference (which is the procedure that arises where two or more inventors by co-pending applications attempt to patent the same invention) because this branch of Patent Law is a very complicated form of specialized litigation and is based upon the legal rights of rival claimants, not on the mere procedure to obtain a patent.

The discussion of "Interferences" therefore belongs under the title of litigation.

Now that we have made a brief survey of the highways and byways through which an application for patent may wander to reach the final goal of the issue of a patent, let us pause and examine the nature of the final document toward which all our effort has been directed. In order to get a clear conception of what it is all about, we must go briefly into the history of patents.

The point from which a subject is viewed has much to do with the conception of the scope and attributes of the subject. The blind men of Indostan went to study the elephant. One grasped the trunk, "The elephant is very like a snake"; another encountered the elephant's leg, "The elephant is very like a tree"; the third, striking the elephant's broad side, said "The elephant is very like a wall."

"And so these men of Indostan
Disputed loud and long,
Each in his opinion
Exceeding stiff and strong,
Though each was partly in the right,
And all were in the wrong."

Patent property and the laws of the United States respecting patent property have come to be viewed from the narrow viewpoint of the specialist. As a narrow base cannot well support a broad shaft, so there is a tendency of the patent system to be dwarfed and restricted through a narrow understanding of the subject.

A United States patent has been held by both eminent scholars and jurists to be a "contract" between the Government and the inventor, the Government offering a privilege and the inventor accepting the offer; the consideration on the part of the Government being the grant for a limited time of the right to exclude others from making, using, or selling the patented invention, and the consideration by the inventor being the full disclosure of a new and useful invention of a specified character. This contract theory of patents upon inventions originated in England, and is set forth in early English decisions. The judges of the United States Courts adopted the wording of those decisions, and the word "contract" in this manner crept into the American jurisprudence and because there seems to have been no substantial analysis of the term, nor objection to it, as applied to patents, the term has stuck.

A study of the early history* of British and American patent law, discloses a point of basic difference, namely that British patents are a grant or favor of the Crown whereas American patents represent a recognition of the rights of citizenship as guaranteed by the constitution of the United States.

The rights of a citizen of the United States and the rights of a subject of a King of England to their respective inventions are today substantially the same where the invention is practiced in secret; i.e., they are relatively unsecured against anything but theft and fraud; but there is a great difference in the laws of these countries for "securing" these rights. In the United States, Congress is empowered to provide laws for "securing" rights to inventions and the inventor has the same inherent right to demand a patent on his patentable inventions that he has to demand and invoke the protection of the law for any other inherent right. The Courts have stated, an application for patent "is practically a lawsuit brought by the inventor to persuade or compel the Government to make a grant of a monopoly to which he thinks himself entitled." In England, an inventor today makes a bargain with the Crown and obtains a patent from the King as a favor under the exercise of the royal prerogative. The legality of such British patent rests on an exception in the general law that struck down the abuses of this same royal prerogative which the inventor must invoke to secure his favor. In the United States an inventor (providing his patent will promote the progress of science and useful arts, and comes within the requirements of patent laws) may *demand* his patent and while the form of his application is that of a petition, he does not present it as a beggar,—an object of charitable reward by a paternally disposed Government. He comes to have his invention clothed in that "security" which the law clearly sets forth to be his "right." The result of the proceeding which clothes his invention in this legal armor against piracy is not a contract, it is not a meeting of the minds, it is not a bargain comprising the offer of a disclosure and the holding out of a grant.

The proceedings leading to the grant of a patent, are an investigation, of necessity requiring disclosure, to determine what has been invented and whether the inventor has complied with the law of the land. He must disclose fully and fairly in order that the investigation may be full and fair. When his invention has been defined, its dimensions in the art measured, and no legal barrier is found, the patent is his by legal as well as inherent right. In order that the world may know just what has been found to be the boundaries of his "secured" property, the instrument evidencing the grant sets forth the precisely defined limits, that is, it defines what the Government is willing to seal as being the invention he is entitled to "claim," i.e., control. When an inventor has complied with the laws provided, the Patent Office is no longer a free agent,—the patent must issue. As the elephant has some of the characteristics defined by the blind men, so a United States patent has some of the attributes of a contract, but to so define a United States patent is to overlook the foundation upon which our patent system stands.

A United States patent therefore is an investiture, securing for a limited time, to one complying with the laws provided, the right to exclude others by due process of law from making, selling, or using a specified invention within the United States and territories thereof, and is evidenced by an instrument under Government seal defining the metes and bounds of the invention as determined by a governmental survey.

* Reviewed in the author's article in the May, 1932, issue of Combustion.

The Davis Coal and Coke Company of Baltimore announce that J. A. Morgan, formerly engineer at their New York office, has been made District Engineer of the Philadelphia territory and will be located at the company's Philadelphia office, Land Title Building.

Burning Petroleum Coke for Steam Generation

This article is a discussion of the article "Burning Pulverized Petroleum Coke Breeze" by E. J. McDonald published in the January issue. The author makes a comparison between the results obtained in burning pulverized petroleum coke breeze at the Northeast Station and those obtainable with a good grade of eastern semi-bituminous coal in a modern water-cooled furnace. In the latter part of the article reference is made to the use of petroleum coke on grates or stokers.

By CARL STRIPE[1]

NORTHEAST Station of the Kansas City Power and Light Company has recently completed a comprehensive investigation of the use of petroleum coke for steam generation and the article "Burning Pulverized Petroleum Coke Breeze," by E. J. McDonald, in January, 1933, COMBUSTION is a notable contribution to the literature on that subject. The data are particularly valuable as they represent the results of a 192-hour test during which the boiler was "operated continuously, receiving normal attention and cleaning."

In comparing the relative values of coal and coke, Mr. McDonald said, "The value of any fuel is, of course, 'relative,' that is, it is worth so much more or so much less than some other fuel for specific purpose."

Quite logically, the author's comparisons are based on the kinds of bituminous coal commercially available at Northeast Station. The pulverizing mills at Northeast were rated on a 9700-B.t.u. coal containing 20 per cent ash and 13 per cent moisture. The chart on mill power consumption shows bituminous coal at 10,325 B.t.u. as fired, 10.5 per cent moisture and 20.5 per cent ash. The calculated figures comparing the heat values of coal and coke are based on 10,500 B.t.u. as fired, which it is assumed, was considered a fair average for the several qualities of coal used at this station. An average of 20 per cent ash and 12 per cent moisture is assumed.

It can be broadly stated that the coals used at Kansas City are among the lowest grade bituminous coals used commercially in this country. In competition with such coals it is not surprising that a favorable showing was made by petroleum coke which analyzes around 15,000 B.t.u. as fired, and contains but 1.25 per cent ash. Under these conditions most favorable for petroleum coke, the following parallel values were found:

	Low-grade Mid-West Coal	Petroleum Coke Breeze
B.t.u. (as fired)	10,500	15,100
Normal rating, per cent	240	274
Maximum rating, per cent	320	375*
Efficiency, per cent	81.78	84.78

*Limited by conditions other than fuel.

Summing up the major factors that determine the relative value of coal and coke, for the particular conditions at Northeast, the author states that the net efficiency of coke is:

3.00% higher due to boiler unit efficiency
.60% higher due to lower draft-fan power
.40% higher due to lower puverizing-mill power and lower induced-draft fan power
.65% lower due to lower superheat

3.35% net difference

With coal-fired operation at 81.78 per cent efficiency, (3 points in efficiency below that of coke-fired operation), the value of coke, considering only the difference in efficiency, would be

$$\frac{3.35}{81.78} = 4.1 \text{ per cent more than coal.}$$

The experience at Northeast showed that the saving due to lower mill maintenance with coke would increase its relative value an additional 3.6 per cent making a total of $4.1 + 3.6 = 7.7$ per cent. Thus, *on the same B.t.u. basis,* 7.7 per cent more could be paid for coke than for coal. However, the relative heat values of the coke and coal at Northeast were established by the author as 15,100 B.t.u. and 10,500 B.t.u. respectively, and hence on a B.t.u. basis the coke would have a value of

$$\frac{15{,}100 - 10{,}500}{10{,}500} = 43.7\% \text{ higher than coal.}$$

The author adds 7.7 per cent and 43.7 per cent and concludes that the sum, 51.4 per cent, represents the margin by which coke is more valuable than coal.

It would be more accurate to consider that 100 and 107.7 are the relative "utilization factors" of coal and coke and that, under the existing conditions, the value of coke exceeds that of coal by

$$\frac{(15{,}100 \times 107.7) - (10{,}500 \times 100)}{(10{,}500 \times 100)} = 55\%$$

[1] Assistant to Vice-President, The Davis Coal and Coke Company.

That is the economic set-up for petroleum coke at Kansas City with low-grade mid-western coal as the unit of comparison, and a refractory furnace. Kansas City would enjoy favorable freight rates on petroleum coke and reasonable reliability of supply because of the close proximity of the producing refineries to the point of consumption.

There can be no criticism of this comparison of coal and coke values provided the figures are recognized as pertaining specifically to the conditions at Northeast and are not broadly interpreted by the casual reader as indicating that similar economic results may be expected in other parts of the country in which the coals commercially available are of very different quality from those used as the standard of comparison at Northeast.

A similar comparison based on conditions in the eastern part of the country may assist in reaching a broader understanding of the economic position of petroleum coke for steam generation.

Perhaps a third of the total installed coal-fired boiler capacity of the United States is located in the north-Atlantic consuming area which includes New England and at least portions of New York, New Jersey, Pennsylvania, Delaware, Maryland and certain adjoining states. The fuel most widely used for steam purposes in this area is semi-bituminous coal from the upper Appalachian field including Pennsylvania, West Virginia, Virginia and Maryland. Based on the use of such coal, burned in pulverized form, and in water-cooled furnaces according to the best modern practice, the following comparisons are made:

	Semi-bituminous steam coal	Petroleum coke breeze
B.t.u. (as fired)	14,100	15,100
Normal rating, per cent	300	300
Maximum rating, per cent	500*	500*
Efficiency	88	86

* Limited by conditions other than fuel.

As measured by the Hardgrove index, the relative grindability of the three fuels herein discussed will average about as follows:

Petroleum coke	100 to 110
Semi-bituminous coal	100 to 110
Mid-western bituminous coal	60 to 70

Petroleum coke and semi-bituminous coal can therefore be placed on a parity as far as grindability is concerned providing the moisture in the coke does not exceed 5 per cent. The test figures at Northeast were based on moisture of 4.3 per cent and the author stated, "Coke has been received with 10 to 11 per cent moisture but trouble is experienced with anything above 7 to 8 per cent due to a heavy rain of sparks and lowered mill capacity; hence, these figures have been set as the maximum moisture for burning."

Petroleum coke is very friable and considerable degradation occurs in transit and handling. The inherent moisture content is low but the surface moisture (which is the part of the moisture that affects pulverization) is largely dependent on the weather during transit and storage, and on the extent of the exposed surface of the coke particles. The surface area varies inversely as the square of any lineal dimension of the average size particle. Hence, the natural degradation and resulting fineness may bring about excessive surface moisture which, in turn, would reduce mill capacity, and increase both the mill maintenance and power for grinding.

Summing up the major factors that determine the relative value of semi-bituminous coal and petroleum coke for the conditions outlined, we find the calculated net efficiency of coal is:

2.0% higher due to boiler unit efficiency
(A slightly higher efficiency with coal can be expected because of the lower carbon losses.)
Same approximate draft-fan power is assumed.
Same approximate pulverizing-mill power and induced-draft fan power are assumed.
Same approximate superheat is assumed.

2.0% net difference

With coke-fired operation at 86 per cent efficiency (2 points in efficiency below that of coal-fired operation), the value of the coal, considering only the difference in efficiency, would be:

$$\frac{2.0}{86} = 2.3 \text{ per cent more than coke.}$$

Thus, the "utilization factors" for petroleum coke and semi-bituminous coal are established at 100 and 102.3 respectively and the actual value of the coke over such coal is

$$\frac{(15{,}100 \times 100) - (14{,}100 \times 102.3)}{14{,}100 \times 102.3} = 4.6 \text{ per cent.}$$

In the foregoing comparison, the performance with petroleum coke is based on the use of preheated air, a water-cooled furnace and operation at slightly higher average ratings than were secured at Northeast. This assumption credits petroleum coke fuel with the ability to utilize the advantages of modern equipment developed for coal firing. The calculated performance for petroleum coke is based on these favorable conditions despite the experience at Northeast where it was found that petroleum coke "is best suited for a refractory-lined furnace and even here low rates of combustion are not easily maintained."

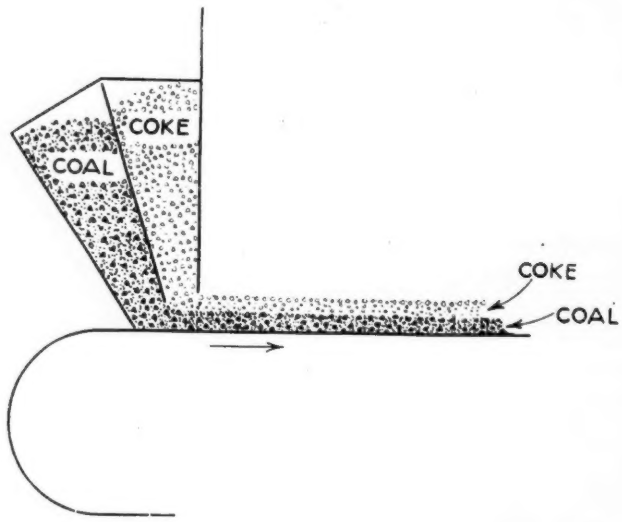
Difficulty is experienced in meeting fluctuating loads with petroleum coke because of the low volatile content and the sluggish ignition characteristics. The rapid absorption of radiant heat in a water-cooled furnace would obviously aggravate this condition by lowering the average furnace temperature.

If it were found necessary to limit the use of petroleum coke to refractory-lined furnaces as was suggested at Northeast, the average efficiency would be lower and operation would be limited to a lower average rating. On this basis, the value of petroleum coke would be definitely less than that of semi-bituminous coal burned accordingly to the best modern practice.

The widely varying moisture content and low volatility of petroleum coke, results in unstable ignition when fired in pulverized form, even in refractory furnaces, with close draft regulation and high CO_2. The use of a pilot burner of either gas or oil is therefore suggested as a safety measure.

The fusing temperature of petroleum coke ash is reported as low as 2160 deg. fahr. Such ash is molten when it enters the tube bank of the boiler and may remain plastic for a sufficient length of time to cause cumulative deposits on the heating surfaces. The ash content is low, less than 1.5 per cent, however, the one boiler unit at Northeast produced over 3600 lb. of ash in twenty-four hours.

The volatile matter distilled from petroleum during combustion in a boiler furnace is not entirely gaseous but contains certain condensable vapors, and, with a high percentage of oil in the coke (as much as 12 per



Diagrammatic vertical section showing arrangement of divided hopper to permit the burning of coal and petroleum coke simultaneously by means of "layer firing" on forced-draft traveling-grate stokers.

cent has been reported) the fuel carbonized on the burners will become over-heated and burn out. The extent of such difficulties depends on the analyses of the coke which may vary widely. It should be remembered that petroleum coke is a by-product and that the quality is dependent on the nature of the oil used and the method and degree of refinement.

Straight petroleum coke cannot be burned satisfactorily on grates or stokers because the low ash content provides inadequate protection for the grates. The report of the investigation of petroleum coke at the Bureau of Mines experiment station at Pittsburgh includes the following statement:

"In one experiment petroleum coke was burned without any protection for the grate bars and the boiler was operated as it would be in severe weather. The grate bars were burned through in twenty-four hours, so that they fell into the ash pit in pieces."

While mixtures of petroleum coke and coal have been burned, there are reports that the coke tends to fuse to the coal and obstruct the proper distribution of air through the fuel bed. Futhermore, it is impossible to maintain a uniform mixture of petroleum coke and coal in bins or pile storage because of the natural segregation of the two fuels owing to the great differences in their specific gravities. The coke is much lighter than the coal. The most satisfactory method from a combustion standpoint is to fire coke and coal alternately when hand fired, and to fill stoker hoppers with alternate shovelfuls of coke and coal, when stoker fired. Obviously, this would represent a tedious and unsatisfactory practice. If attempts are made to mix these dissimilar fuels in bins, segregation is certain to occur with the result that some areas of the grate (or stoker) receive straight coke. The absence of sufficient ash protection will cause rapid overheating and failure of the grate (or stoker) at these areas.

With forced-draft traveling-grate stokers, petroleum coke has been burned successfully in combination with coal, by means of "layer firing". In this method, the stoker hopper is divided transversely by a baffle as shown in the accompanying sketch. Coal is fed next to the grate and provides the necessary ash protection for the stoker. The coke is fed in a thin layer on top of the coal.

Tentative National Standard for Abbreviations of Technical Terms Published by A. S. M. E.

Frequent misunderstandings among scientists and engineers because of a confusion of different abbreviations for technical terms used in their writing have led to the establishment, under the auspices of the American Standards Association, of a tentative national standard for abbreviations for the most common scientific and engineering terms.

The standard, covering abbreviations ranging all the way from acres to kilovolt amperes, has just been published by the American Society of Mechanical Engineers, one of the five national engineering and scientific organizations which are taking the leadership through the agency of the American Standards Association in the preparation of a long series of national standards for technical symbols, as well as abbreviations for all branches of science and engineering. The other four organizations are the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, and the Association for the Promotion of Engineering Education.

J. Franklin Meyer, National Bureau of Standards, Washington, D. C., is chairman of the technical committee which is in charge of the developments of the standards, under the direction of these organizations.

The Patterson Foundry & Machine Company, East Liverpool, Ohio, announce their entrance into the stoker field.

The following district representatives have been appointed to handle their commercial and industrial stokers, ash conveyors, cast iron ash storage tanks and soot blowers:

The Homer-Read Company, Vandergrift Building, Pittsburgh, has been assigned the Pittsburgh territory; Horace S. Bracken, Johnstown, Pa., the Johnstown territory; and R. W. Matthews, 770 Girard Street, N. W., Washington, D. C., the District of Columbia.

EMPLOYMENT SERVICE

This page is contributed by COMBUSTION for the benefit of unemployed engineers who are qualified to assume responsibility for the design, construction or operation of steam power plants.

There are many plants today which could save thousands of dollars annually by taking advantage of the opportunity which present conditions afford to secure the services of highly trained and experienced men at moderate salaries. Some of the engineers listed on this page have been employed by the largest engineering firms in the country in important positions and at salaries commensurate with their abilities. As soon as business conditions improve the services of these men will be in demand and will not be available at any such salaries as they are now willing to accept.

COMBUSTION hopes it will have the privilege of bringing these engineers into contact with those who can profitably employ them.

A-20. *Education:* Mechanical Engineering, Glasgow University, Royal Technical College (evenings), Teachers College, Boston. *Experience:* 1931 to 1932 engaged by a large chemical company as Steam Engineer in charge of power plant design and assistant engineer on alkali plant design. From 1923 to 1931 was engaged successively by one of the largest consulting engineering firms and by several very prominent industrial organizations, as engineer in charge of drafting supervision, design calculations and specifications. Has had extensive experience with high pressure steam plants, having been responsible for the initial estimate, preliminary layouts, design, manufacturing and field engineering, and preliminary operation of a 900 lb. steam plant. Also experience as above with a 1200 lb. power plant and with development work, design and manufacture of 3000 lb. pressure equipment.

A-21. *Education:* Completed course at Hays School of Combustion. *Experience:* This man has been engaged for seventeen years as chief engineer for several large industrial organizations, 10 years of which were as chief engineer of the largest salt plant in the world. This applicant is particularly qualified to serve as superintendent of power or chief operating engineer.

A-22. *Education:* Electrical Engineering, Stanford University. *Experience:* This man has had experience in various fields. After graduating from Stanford he became student engineer in a large electrical manufacturing company, winding up as commercial service engineer. Thereafter he went to Mexico as an engineer for a mining company and cotton mill and finishing house. His experiences included the designing and building of power house. He also served as superintendent of power of a coal company having a 2400 hp. boiler plant. He has had extensive experience in the operation of power plants and as combustion engineer.

A-23. *Education:* General engineering course, Polytechnic Institute, Structural steel design course, Pratt Institute. *Experience:* This man was engaged by a large electric manufacturing company from 1928 to 1932, as engineer in charge of design and purchase of power plant equipment and as resident engineer in charge of heating, plumbing and ventilating. He was previously employed, successively, by a large paper company, a contractor and a large oil company. He has been engaged as general paper mill designer and has wide experience with the design of piping for mill and power plants and with structural steel design. This man also has had experience with the laying out of heating and power plants.

A-24. *Education:* Special studies in combustion and power plant engineering and refrigeration. *Experience:* This man has been inspector of boilers, engines, turbines, elevators and electrical machinery for a large casualty company for the past eight years. Previously he served as chief engineer of one of the plants of a large gas and electric company. He had formerly been engaged as shift engineer and in shop and erecting work. This man speaks Spanish fluently.

A-25. *Education:* Mechanical Engineering, A. & M. College of Texas, special engineering courses at Stevens, University of Wisconsin and Purdue University. *Experience:* This man was engaged in teaching various engineering subjects from 1896 to 1916. For the last eleven years of this period, he was the head of the mechanical engineering department of a southern university. He developed courses in sugar engineering and carried on investigations of machinery in sugar factories. Has presented papers before the A.S.M.E. in 1913 and 1916. This man has also been identified with a large sugar company for which he was in charge of improving the efficiency of the heat equipment consisting of boilers, bagasse and oil furnaces, evaporators, heaters, vacuum pans, condensers, piping, locomotives, etc. Has made steam surveys and effected material fuel savings.

A-26. *Education:* Electrical engineering course, home study. *Experience:* This man has been assistant power plant engineer for an oil company. He has had considerable experience with furnaces and particularly gas and oil furnaces. He has invented and patented a gas furnace. He has also had experience in the electrical field, having served as electrical superintendent of a mining company for two years.

A-27. *Education:* Electrical Engineering, Pennsylvania State College, business administration, Alexander Hamilton Institute. *Experience:* Engaged by one of the most prominent consulting engineering firms for the last three years. His activities in this organization included the correlation of engineering work for four recently constructed power stations and industrial power plants. He was previously identified with five large industrial organizations from 1911 to 1928. He has had extensive experience with pulverized coal, fuel oil, compressed air and water services to refineries and in the design and servicing of steam-electric power plants.

A-28. *Education:* B.S. in Mechanical Engineering. *Experience:* One year as Efficiency Engineer. Conducted tests on steel plant equipment, boilers, furnaces, etc. Has had experience with microphotography. Has served as mechanical designer for one year in charge of the engineering and drafting required in the modernization of ice plants and water works. Has been mechanical designer responsible for the design of piping for large steam power plants. Has also had additional experience in checking conveyors and duct work and in miscellaneous mechanical and electrical design and layout work.

A-29. *Education:* Mechanical Engineering, Georgia School of Technology. *Experience:* Has been identified with an architectural and engineering firm in the South for the past six years. For four years served as chief engineer of power plants and pumping stations for a large chemical company down South. Has had operating and maintenance experience with producer-gas engine power plants, diesel power plants and steam-turbine power plants. Previously was identified with the same company as assistant chief engineer for three years. The last nine years of this man's work have been along consulting engineering lines.

Note: Space limitations make it impossible to present adequately the detailed experience and qualifications of the above applicants. The fact that many of them have had similar experience will make it difficult for those interested in their services to make a selection. Consequently, COMBUSTION will be glad to assist inquirers from the detailed information in its files by making recommendations as to applicants who are best qualified for particular positions, or will give the inquirer more detailed information concerning particular applicants. Where inquiry is made concerning certain applicants, as identified by number, such applicants will be asked to communicate directly with the inquirer unless otherwise requested. All inquiries should be addressed to COMBUSTION, Attention of Editor, 200 Madison Avenue, New York.

NEW EQUIPMENT

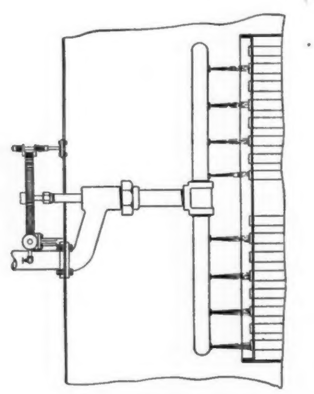
of interest to steam plant Engineers

Soot Blowers

Diamond Automatic Air Puff Soot Blowers were developed to meet the need for cleaning of boilers where the low operating pressure prevented the use of steam as a cleaning medium.

The Diamond A-1 Air Puff Soot Blower System for fire tube boilers consists of: an air compressor; an air storage tank; one pressure actuated control valve; one pilot valve; one diaphragm member in connection with the pilot valve; and, for each boiler: one blower arm, one piston and gear to rotate blower arm, and connecting pipe, valves, fittings, and wiring.

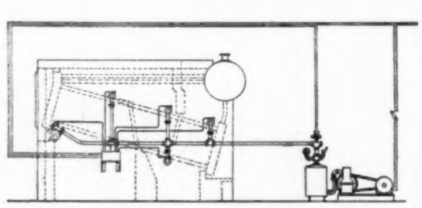
Operation, with the exception of the hand operated air control valve for each boiler, is entirely automatic. The pressing of a push button starts the compressor, and when air pressure in the storage tank has reached 120 lb., the pilot valve opens the main control valve, and the



A1 Blower Installation.

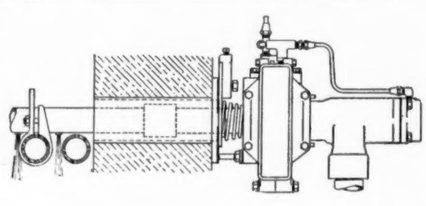
blower mechanism begins operation. The blower rotates step by step and blows in puffs as long as air pressure remains between 80 and 120 lb., or until its blowing arc has been completed. When the full 360 deg. has been traversed, the boiler has been cleaned, and its control valve is closed. Each boiler is fitted with its own individual blower mechanism but only one air compressor and receiver unit is required for servicing the entire battery.

The Diamond A-2 Air Puff System for water tube boilers consists of: an air compressor; an air storage tank; a pressure actuated switch; and, for each boiler: one controller with switch, one electrical interrupter for timing the duration of



each blow, one air control valve, the required number of soot blower units, and connecting pipe, valves, fittings, and wiring.

This system is operated by the pressure of a push button and the opening of the air control valve and the closing of the controller switch to boiler. From this point blower operation is entirely automatic. When pressure in the air storage tank reaches 120 lb. the first blower unit begins operation. This unit continues to



A2B Blower Head.

rotate in steps and blows in puffs as long as pressure remains between 80 and 120 lb. or until it completes its blowing arc. When pressure drops to 80 lb. blowing ceases until the compressor again builds up the pressure in the storage tank to 120 lb. When the first unit completes its blow, it is automatically cut out by the controller and the second unit is cut in. This continues until each unit has been operated, when the blower system for the boiler shuts down.

New Light Cleated Belt Conveyor

A new cleated belt conveyor has just been announced and placed on the market by the Barber-Greene Company of Aurora, Illinois.

This machine, known as the Barber-Greene "Seventy," is built in three lengths, 21 ft., 25 ft. and 31 ft., and two widths, 14 in. and 18 in. (31 ft. length built only in 18 in. width.) This machine is used for handling coal, coke and similar bulk materials.

One of the features claimed for this conveyor is the ease with which the boom

can be raised from any position. A highly simplified truck and hoist design makes this feature possible, and makes it easy for the operator to adjust the discharge height thus saving coal breakage.

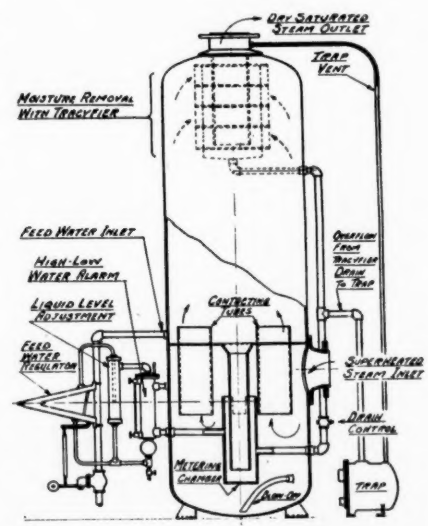
Other features of the machine include standardized sectional construction, 12 in. welded steel truss, 7½ in. trough, crowned lagged 8 in. head pulley, divided cleats, taking full advantage of pulley crown, return guide rollers, assuring positive belt alignment, head end take-up, fixed rigid tail end where strength is most needed, low foot end for easy shoveling and small pits, and detachable hopper plates for the foot end.

On this conveyor, the return belt does not drag, but is supported by a squirrel cage return roller. The return belt is protected for its entire length by decking.

The truck and hoist design allows the boom to be lowered down to a very small minimum discharge height, preventing breakage when starting a pile or working in tandem. The maximum angle of operation is 35 deg. A 3 ft. 6 in. screen and veil plate are furnished with the machine. Alemite lubrication is used throughout.

Desuperheater

The Blaw-Knox Company of Pittsburgh, Pennsylvania, has added to their line of steam power equipment a desuperheater based on an entirely new principle. This apparatus, completely desuperheats and purifies the steam. While the design is distinctly new in desuperheating, the main parts have been amply proven in standard equipment over a long period of time. Essentially the Blaw-Knox Desuperheater consists of a Blaw-Knox Contactor combined with a Tracyfier (steam purifier) and equipped with a standard make of boiler feedwater regulator. The principal advantages claimed for the new Blaw-



Knox Desuperheater are as follows: A single unit to install; a simple and practically fool-proof piece of apparatus which receives the superheated steam and delivers dry, saturated steam, absolutely clean.—Due to the inherently automatic functioning of the Blaw-Knox Desuperheater, no delicate temperature regulating means is required, nor other delicate regulating devices for proportioning amount of water required to amount of steam passed.—This regulator insures an ample supply of water present in the Desuperheater at all times. By the action within the Desuperheater, a very large supply of water is automatically forced into intimate contact with the steam, insuring complete elimination of superheat. Due to this same action and the fact that a very large surplus of water is in contact with the steam, changes in quantity of steam passed, increases or decreases in the amount of superheat, or changes in pressure are automatically cared for.

Due to the design of the Blaw-Knox Desuperheater, any solids carried in the superheated steam are retained by the

water and gradually concentrated, eventually being removed by the required amount of blow-downs. Any solids contained in the water mist above the contacting tubes are prevented from leaving the Desuperheater by the mist extractor.

The Tracyfier (Steam Purifier) is the "mist extractor" used. Its use insures the delivery of clean, dry steam.

Automatic Feed Water System

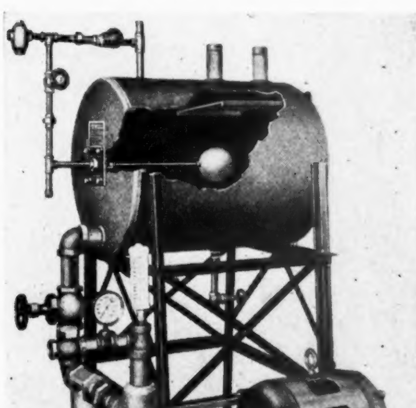
After several years of experimental work, the Fred H. Schaub Engineering Company, 325 West Huron St., Chicago, Ill., has placed on the market the Schaub Boiler Return System.

The elements of this system comprise the Schaub Boiler Control, an electric motor-driven super-turbine pumping unit, Schaub Strainers, relief valve and pressure gage. Where necessary an automatic electric line starter is also furnished.

The operation of the Automatic Feed Water System is as follows: the suction side of the pump is connected directly to the city water line (or hot water system if available) and the discharge side of the pump is connected directly to the boiler. The pressure gage is located on the discharge side of the pump followed by the relief valve. The strainer is located on the suction side of the pump.

The float operated electric Control is connected to the boiler, so that the steam and water in the boiler circulate through it. When the water level in the boiler drops a fraction of an inch (adjustable) the Control engages the electrical contact to the motor driven pump and the water either from the city water line or hot water storage system is pumped into the boiler. As soon as the water level in the boiler rises to normal position, the Control disengages the electrical contact and the pumping stops.

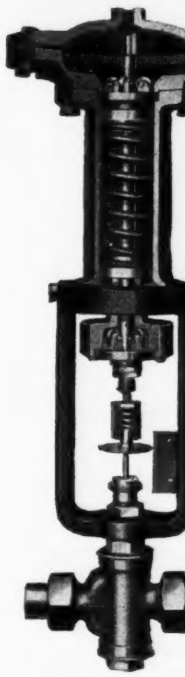
By maintaining a uniform water level, uniform steam pressure is likewise maintained, reducing fuel consumption and providing a balanced steam supply for plant operation. Elimination of manual attention to the water requirements of the boiler reduces operating cost further. Boiler horsepower is greatly increased in addition to the benefit derived in protecting the boiler against low water damage.



Diaphragm Valve

The C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, New York, has placed on the market a new valve—the TAG Friction-Free Diaphragm Valve. This improved superstructure is mounted on TAG V-port Balanced Valves thus giving it gradual opening characteristics.

Friction is claimed to have been cut down to a minimum by reducing the diameter of the spindle passing through the stuffing box. The spindle is perfectly guided by its upper (large diameter) portion which passes through two roller bearing assemblies, each consisting of four stainless steel rollers.



The spring (single or multiple) is enclosed as is also the diaphragm; a positive indicator is furnished; adjustments are easily made available with 7½ in., 9½ and 11½ in. diameter diaphragms.

Indicating Recorder

A new round-chart Micromax Indicating Recorder has been placed on the market by Leeds & Northrup, 4901 Stenton Ave., Philadelphia, Pa.

This junior instrument is not capable of all that the strip-chart Micromax can do, but it is claimed to bring the outstanding reliability and the easy, low-cost maintenance of the motor-driven null recorder to a price class that has never enjoyed these advantages before.

This low-cost dependability is especially valuable in pyrometers of about 400 to 1000 deg fahr. range, because three of the Micromax features are especially valuable in processes that use those temperatures. These features are, first, the temperature detector (thermocouple or resistance thermometer) has extremely long life; second, it may be replaced when necessary without sending the Recorder back to the factory, and, third, it may be installed at any distance from the Indicating Recorder or shifted from place to place at will. This instrument is also claimed to be especially adapted to the recording of temperatures across the entire ranges of thermocouples, of resistance thermometers, to the recording of smoke density, liquid level, SO_2, speed, solar radiation and many other applications. This instrument has a boldly-lettered circular scale which can be read at a glance across a large room. It uses a 24-hour circular chart. The chart has straight-line time coordinates instead of curved ones, thus further increasing the readability. It is one of the few round-chart recorders with such coordinates. The calibrated portion of the chart is 3½ in. wide, and the chart is 10⅜ in. in dia. overall. The Recorder is made as a single-point instrument only, and can be equipped with two signal or control contacts. Potentiometers are manually standardized. The mechanism is accessible, and is mounted on a frame that is hinged to the case. The mechanism may be swung out of the case if desired. The case is 16½ in. dia., and may be mounted either flush or hung on the face of a wall or panel as specified.

New Electrode Holder for Atomic-Hydrogen Arc-Welding

A new type electrode holder has been developed by the General Electric Company for atomic-hydrogen arc-welding with flexible tungsten electrodes. These flexible electrodes are carried in curved tubes, forming a part of the holder, and are brought into position through the means of a screw feed ejector.

The flexible tungsten electrode is made up of several small diameter tungsten wires which have been stranded together, and, as a result, the electrode is so flexible that the ends of a 12-inch length can be brought together without giving the electrode a definite set. The consumption of this electrode is the same as that of the rod type electrode.

When using the rod type holder, the operator has a tendency to discard the electrode after it has been consumed to a length of three or four inches because of the difficulty of adjusting the shorter lengths. In the new holder, the electrode is easily adjusted, by means of the screw feed ejector, and can be consumed to a length of approximately one and one-half inches, at which point the electrode will drop out of the nozzle tip. Before this occurs, a new electrode has been mechanically inserted into the ejector and a few turns of the screw feed places the electrode in welding position.

On holders of the rod type, the hydrogen tubes are moulded into the handle and, therefore, whenever these tubes have to be repaired or replaced, it is generally necessary to return the holder to the factory. The tubes of the new holder are easily detached from the handle and the purchaser can make any necessary replacements at his own plant. Likewise, all other wearing parts have been arranged for quick and easy replacement.

NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Armorite

A four page insert has been published by the B. F. Goodrich Rubber Co., Akron, Ohio, for its mechanical goods catalog. Armorite, a soft, elastic black rubber, is used as a protection to surfaces from abrasion of wet or dry materials.

Conveyor Belts

A four page insert has just been published by the B. F. Goodrich Rubber Company, Akron, Ohio, on its Maxecon General Service Conveyor Belt and Improved Hot Material Belt. This insert describes the construction and shows typical applications of the two types of belting.

Conveyor Belt Trainer

Bulletin 84 describes the Robins Self Training Belt Conveyor. 4 pages, 8½ x 11—Robins Conveying Belt Company, 15 Park Row, New York, N. Y.

Diesel Engines

A very comprehensive catalog No. 932-F has just been issued setting forth the design and construction features of the Atlas Imperial Stationary Diesel Engines. Many illustrations of the installations of these engines are shown. 32 pages and cover, 8½ x 11—Atlas Imperial Diesel Engine Co., Oakland, California.

Draft Gage

Bulletin No. 15 describes the new Ellison Portable Draft Gage Sets. Series 35. 8 pages 4 x 9¼—Ellison Draft Gage Company, 214 West Kinzie Street, Chicago, Ill.

Expansion Joints

Bulletin EJ-1904 has just been issued describing the Yarway Cylinder-Guided Expansion Joints. These joints are particularly suitable for restricted spaces in tunnels, manholes, buildings and ships. They can be furnished in wrought steel or cast bronze, with flanged, welded or screwed connections; for 150, 300 and 400 lb. working pressures. 16 pages, 8½ x 11—Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pa.

Feed Water Treatment

Bulletin No. 695 on zeolite softeners discusses the several systems of water treatment and their respective fields of use. The chemistry of softening is set forth, and is followed by a description of the zeolite softener apparatus and an explanation of methods of rating zeolite softeners. The meanings of hardness of water in terms of calcium carbonate and of compensated hardness are explained. 16 pages, 8½ x 11—Cochrane Corporation, Philadelphia, Pa.

Floating Fan Base

A two page insert has just been issued by the Buffalo Forge Company, Buffalo, N. Y., describing their newly developed silent, floating fan base.

Flow Meter With New Magnetic Clutch

Broadside No. 1058 describes a recently developed line of TAG Flow Meters with a new Magnetic Clutch. This broadside is an interestingly arranged publication including a complete description and many large illustrations. 32 pages, 8½ x 11—C. J. Tagliabue Mfg. Co., Park and Nostrand Avenues, Brooklyn, N. Y.

Lubrication

Re-refining 12 Brands of Oil is the title of a bulletin including the Laboratory Report of Re-refining Tests conducted at the Tide Water Oil Company's Testing Laboratories, Bayonne, New Jersey. The re-refining practice of this laboratory is set forth in detail. 28 pages, 5½ x 7¾—Tide Water Oil Company, 17 Battery Place, New York.

One-Way Free-Wheeling Clutch

A catalog has just been issued describing the Columbia One-Way Free-Wheeling Clutch. This catalog includes many illustrations and a table of data. 10 pages with cover, 7½ x 10½—Engineer's Specialty Co., 549 West Randolph St., Chicago, Ill.

Speed Reducers

Catalog No. 27 describes the Smith Speed Reducers and Transmission Machinery. This catalog has a clever indexing device whereby it is possible to pick out the information desired in the catalog, so to speak, by a stroke of the thumb. 44 pages and cover, 5½ x 8—Winfield H. Smith, Inc., Springville, Erie Co., N. Y.

Stainless Welded Tubing

A folder entitled Carpenter Stainless Welded Tube has been issued recently. This welded tubing is made from cold rolled stainless strip steel. The weld is made automatically under exact control and is scarcely distinguishable from the rest of the tube. The folder gives information relative to outside diameter, weld thickness, size tolerance, shapes and finish, etc. A table of physical properties is also shown together with working instructions. 6 pages, 6¼ x 9¼—The Carpenter Steel Company, 100 Broadway, New York.

Steam Traps

Bulletin No. 59 describes the Strong Steam Traps. This bulletin includes several illustrations and tables of data. 4 pages, 8½ x 11 The Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Steam Turbines

A new catalog has just been printed describing the General Electric Company Steam Turbines for Mechanical Drive. The construction of this turbine is set forth in great detail and is also illustrated by many illustrations. A discussion on the applications of this turbine is included. 16 pages and cover, 8½ x 11—General Electric Company, Schenectady, N. Y.

Stokers

A pamphlet has just been published entitled The Stott Synchromatic Firing-Ram Type Stoker. The description of the stoker is accompanied with several clear illustrations. These stokers are applicable to both the industrial plant and small apartments and buildings. 6 pages, 8½ x 11—Stott Briquet Company, Inc., St. Paul, Minn.

Valves

A pamphlet has just been published by Schutte & Koerting Company describing their Special Fuel Oil and Lubricating Oil Relief Valves with Compensator. 2 pages, 8½ x 11—Schutte & Koerting Company, 12th and Thompson Streets, Philadelphia, Pa.

Welded Pipe, Casing and Tubing

Catalog 210B entitled Republic Electric Weld Line Pipe Casing describes the new line which this organization has developed in recent years. Some of the headings in this catalog are as follows: "Twenty Years of Pipe Progress with Republic"; "Republic Electric Weld Pipe in the Making"; "Typical Joints for which Republic Electric Weld Pipe can be Supplied." 36 pages and cover, 8½ x 11—Republic Steel Corporation, Massillon, Ohio.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION
200 Madison Ave., New York

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

1932 Proceedings

Thirty-Fifth Annual Meeting
American Society for Testing Materials

THE American Society for Testing Materials has just issued the Proceedings of its Thirty-Fifth Annual Meeting, held in Atlantic City, N. J., June 20-24, 1932. As is customary, the Proceedings is issued in two parts, as follows:

Part I:—*Committee Reports. New Tentative Standards. Revisions of Standards.* This volume of the Proceedings contains the annual reports of the many Society committees, and the technical papers and standards appended thereto. The annual address of the President, entitled "Research and the American Society for Testing Materials," and the report of the Executive Committee are also included.

The reports of the standing, research and sectional committees which function in the ferrous metals fields include such subjects as the following: Steel; wrought iron; cast iron; malleable iron castings; ferro-alloys; iron-chromium; etc. The reports of the non-ferrous committees cover their activities in the following fields: Copper wire; corrosion of non-ferrous metals and alloys; electrical-heating; etc. Reports covering non-metallic materials include the following: Cement; clay pipe, drain tile; etc. Other reports cover: Preservative coatings for structural materials; road and paving materials; coal and coke; timber; bituminous waterproofing and roofing materials; metallography; nomenclature and definitions. Part I also includes the 85 tentative standards issued or revised in 1932, as well as the many tentative revisions in standards.

Part II:—*Technical Papers.* This volume of the Proceedings includes the many technical papers presented at the annual meeting and discussions thereon. By including in the Proceedings the extensive oral and written discussions of the papers, there is retained in permanent form the views of many technologists on the subjects. Often additional data are given and these, with the various views presented, clear up points on which there are uncertainties. Herein lies one of the real values of the Proceedings.

Part II includes many papers dealing with important problems and subjects relating to the ferrous and non-ferrous metals industries. Ten extensive papers are grouped in the Symposium on Steel Castings, covering statistics, specifications, design, physical and mechanical properties, corrosion, heat treatment and welding of both carbon-steel and alloy-steel castings. A report of the extensive research investigation on embrittlement of hot-galvanized structural steel is given. Other papers cover mechanical and magnetic properties of 1.21-per-cent carbon tool steel, and effect of zinc coatings on endurance properties of steel. There are papers on factors affecting the Preece test for zinc coating and mechanism of deformations in gray iron. Non-ferrous subjects covered are mechanical properties of white-metal bearing alloys at different temperatures, method of preparation of lead and lead alloy cable sheath for microscopic examination, and effect of cold working on Izod notched-bar impact value of monel metal. Seven papers cover various aspects of textiles, asbestos textiles, structure and properties of the rayons, colorimeter and method employed in the color testing of cotton, and a machine test on the durability of manila rope. Three of the technical conditions involve the firmness and particle size distribution of portland cement, tests on consistency and strength of concrete having constant water content, and volume changes of an early-strength concrete. Some of the subjects discussed in other papers are: a rapid method of determining the specific gravity of pigments and powders; application of control analysis to the quality of varnished cambric tape; and volatile combustible matter of coal-tar pitch.

Part I of the Proceedings contains 1071 pages and Part II 824. Each part is available at the following prices: Paper binding $5.50; cloth binding $6.00; half-leather $7.00.

Steam Power Plant Engineering

by Louis Allen Harding

THIS book, a complete revision of Vol. II of "Mechanical Equipment of Buildings," the publication of which has now been discontinued, comprehensively covers the major problems involved in the design of power plant apparatus, the rating of the apparatus, their co-relation in the scheme of power plant engineering, and the economic factors involved in their selection.

Beginning logically with a discussion of fuels and combustion, the author proceeds with the treatment of boilers, furnaces, stokers, pulverizers, oil burners, superheaters, desuperheaters, resuperheaters, economizers, air preheaters, feed-water heataers, deaerating heaters, evaporators, water purifiers, pumps, steam engines, turbines, regenerators, reheaters, condensers, cooling towers, pipes, fittings, valves, heat coverings, accessories, etc.

The information contained in this book is thoroughly up-to-date and in accord with modern practices. It is written by an engineer of wide experience and should prove of value to any engineer whose work and interests lie in the steam power plant field.

This volume, size 6 x 9. is well illustrated and contains 777 pages. Price $10.00.

BOOKS

1—A.S.T.M. Tentative Standards —1932

1236 Pages Price: Cloth cover $8.00
Paper cover $7.00

The 1932 book of A.S.T.M. Tentative Standards includes all of the 226 tentative specifications, test methods, definitions of terms and recommended practices effective as of October 31, 1932. Of this number 47 were accepted for publication for the first time in 1932. The items covered include ferrous and non-ferrous metals, cement, lime, gypsum, concrete and clay products, preservative coatings, petroleum products and lubricants, road materials, coal, coke timber, timber preservatives, shipping containers, waterproofing and roofing materials, slate and building stone, electrical insulating materials, rubber products, textile materials, and a number of miscellaneous materials. A comprehensive subject index and a complete table of contents are also contained in this volume.

2—Pulverized Fuel Firing

By Sydney H. North

204 Pages Illustrated Price $2.25

The author of this book, an Englishman, briefly reviews the history of pulverized fuel as a prelude to a discussion of its development to the present day. Contemporary designs of furnaces, burners, feeders, pulverizing mills, driers, dust collectors, etc., are described and illustrated, as are actual installations in America and Europe which exemplify the trends of practice. Chapters are devoted to the combustion of pulverized fuel and its use in connection with Lancashire boilers, marine boilers and in metallurgical furnaces.

3—Kempe's Engineer's Year-Book for 1932

3000 Pages 7 x 5 $7.00

This publication brings together all the technical information which an engineer has to use day by day. It is a library in itself, a veritable encyclopaedia of modern practice in civil, mechanical, electrical, marine, gas, aero, mine and metallurgical engineering. It is of value to the practicing engineer, the consultant, the manufacturer, power user, contractor, works manager, draftsman and technical student. In this new edition, the 39th, up-to-date information and tables have been introduced, old matter re-arranged, and obsolete material omitted.

4—A Handbook of English in Engineering Use

By A. C. Howell

308 Pages Price $2.50

Here is a real up-to-the-minute handbook that should be on the desk of every technical writer. Most engineers have occasion to do considerable writing and will find this useful. Chapters are devoted to word usage and idioms, sentence and paragraph structure, composition, punctuation and the mechanics of writing and grammar. Examples cover letters, reports and technical articles.

5—Technical Data on Fuel

Edited by H. M. Spiers

302 Pages 5½ x 7 $2.75

Technical Data on Fuel, originally published as one of the British contributions to the Fuel Conference, held in London at a Sectional Meeting of the World Power Conference in 1928, was so enthusiastically received by engineers of all countries that within four years two editions have been exhausted and a third, completely revised, has just been issued. Further data have been added to this new edition, and the contents are now approximately 75 per cent greater than the contents of the first edition. This volume was prepared with the close co-operation of leading British fuel technologists under the editorship of H. M. Spiers of the Research Section of The Woodall-Duckham Companies.

The book is divided into 14 main divisions and numerous sub-divisions. The main divisions are as follows: General Information (Atomic Weights, Logarithms, Antilogarithms, etc.); Air, Water and Gases; Specific Heat; Thermodynamic Properties of Materials; Thermal Conductivity and Heat Transfer; Metals and Alloys; Refractories; Fuel—General Introduction; Gaseous Fuels; Liquid Fuels; Solid Fuels; Stack Losses; Miscellaneous Thermal Data; and Bibliography.

6—Steam Power Plant Engineering

By G. F. Gebhardt

1036 Pages Price $6.00

One of the truly standard reference books on mechanical engineering. It is a necessary part of the equipment of everyone who has to do with steam-power plant engineering.

7—Examination of Water (Sixth Edition 1931)

(Chemical and Bacteriological)

By William P. Mason. Revised by Arthur M. Buswell

224 Pages 6 x 9 Price $3.00

This book, published thirty-two years ago, has proved its value and reliability through constant and wide-spread service. It is known as one of the best authorities on the subject The present edition is a great improvement over previous editions. Although changes have modernized the book completely, the aim of the book remains unchanged—to give suggestions for the determination of mineral matters in water and present such material on the bacteriological examination as has been demonstrated to be of real service to the water examiner.

8—Steam Tables and Mollier Diagram

By Joseph H. Keenan

Price $2.00

These new Steam Tables, extending to a pressure of 3500 lb. per sq. in. and a temperature of 1000 deg. fahr., were developed from the latest experimental data secured by investigators in laboratories of Europe and those of the United States. The symbols used in this work are taken from the latest test prepared by the A. S. A. Sub-Committee for Heat and Thermodynamics. A large copy of the new Mollier Diagram (23" x 34") is also included.

9—Water Analysis

By Herbert B. Stocks

135 Pages $3.50

Public health officers, city chemists and those engaged in the study of this branch of analytical work will be interested in this new edition of a book which has long been a standard in this country and England on the subject of the methods adopted for the analysis of water for sanitary and technical purposes. It has been completely revised, rearranged and added to by W. Gordon Carey.

Modern developments have necessitated new sections dealing with hydrogen ion concentration, the determination of free chlorine in chlorinated water, and the determination of iodides. A section on simple bacteriological methods is included in this edition, and should prove of service to those who use this book.

10—Mechanical Engineers' Handbook

By R. T. Kent

2247 Pages 10th Ed. Price $6.00

Designer, power-plant engineer, shop-superintendent, heating and ventilating engineer, hydraulic engineer, building constructor, foundryman, automotive engineer, will find this handbook to be a complete reference book covering their field and many others. "Kent" is more than a book, it is a complete library of engineering practice.

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

IN-CE-CO PUBLISHING CORPORATION,
200 Madison Avenue, New York.

Enclosed find check for $.... for which please send me the books listed by number

NAME ....

ADDRESS ....

Books Nos. ....

American Standards Association Elects Officers for 1933

The election of Howard Coonley, president of the Walworth Company, New York, to the presidency of the American Standards Association for the year 1933 was recently announced at the Association's headquarters. The election of Mr. Coonley, who is also a director of several industrial, insurance, and banking organizations, to head the national standardization work in which over 570 organizations and 2700 individuals are engaged, follows several years of active connection with the standardization movement as the representative of the American Society of Mechanical Engineers and the mechanical industries. Mr. Coonley succeeds Bancroft Gherardi, vice-president of the American Telephone and Telegraph Company, as the president of the American Standards Association.

The election of F. E. Moskovics, chairman of the Board of Directors of the Marmon-Herrington Company, Indianapolis, to the vice-presidency of the Association is also announced. Mr. Moskovics, who was formerly vice-president of the Franklin Automobile Company, and president of the Stutz Motor Car Company, has represented the Society of Automotive Engineers in national standardization work for some time.

The American Society for Testing Materials has just issued the 1932 Index to A.S.T.M. Standards and Tentative Standards. This pamphlet is designed to be of service both to those familiar with A.S.T.M. standards and those who are not. Its value to the former group is in locating any specification or method of test in the bound Society publication in which it appears. To both groups the Index is a very convenient reference in ascertaining whether or not the Society has issued any standards on a specific subject.

Copies are furnished without charge to those who send a request to Society headquarters, 1315 Spruce Street, Philadelphia.

The 6th Midwest Engineering & Power Exposition will be held during the week of June 25, 1933, instead of in February as formerly. The change has been made to give engineers attending "Engineering Week" an opportunity to transact business with a large group of manufacturers who will be showing their products at the Power Show. Early indications point to a complete utilization of the 85,000 square feet of floor space at the Coliseum Building with exhibits of machinery, equipment and supplies portraying the latest advances in the various wide uses of power — from ordinary power-operated tools to large generators, engines, pumps, and other equipment of like importance.

The educational features of the Power Show will be sponsored by the Armour Institute of Technology, Chicago, and Mr. George F. Gebhardt, professor of mechanical engineering, will be in direct charge. It is hoped that these features will be particularly beneficial to every engineer as they will cover the broader aspects of the professional and practical side of power engineering encountered in actual practice.

Boiler, Stoker and Pulverized Fuel Equipment Sales

As reported by equipment manufacturers to the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 291 boilers were placed in November by 72 manufacturers

	Number	Square feet
November, 1932	291	310,523
November, 1931	464	389,537
January to November (inclusive, 1932)	3,359	3,218,259
Equivalent period, 1931	7,118	5,956,022
Total, 1931	7,508	6,327,262

NEW ORDERS, BY KIND, PLACED IN NOVEMBER, 1931-1932

	November, 1931		November, 1932	
Kind	Number	Square feet	Number	Square feet
Stationary:				
Water tube	42	142,933	29	181,618
Horizontal return tubular	21	26,119	37	49,091
Vertical fire tube	54	16,224	31	9,093
Locomotive, not railway	12	7,302	1	226
Steel heating	306	180,910	189	69,234
Oil country	3	1,695	....	....
Self contained portable	20	11,112	3	1,085
Miscellaneous	6	3,242	1	176
Total	464	389,537	291	310,523

Mechanical Stoker Sales

Orders for 91 stokers totaling 13,283 hp. were placed in November by 55 manufacturers

	Installed under			
	Fire-tube boilers		Water-tube boilers	
	No.	Horsepower	No.	Horsepower
November, 1932	79	10,105	12	3,178
November, 1931	170	23,340	36	8,731
January to November (inclusive, 1932)	842	110,572	347	132,572
Equivalent period, 1931	1,772	235,537	552	179,988
Total, 1931	1,889	252,571	574	187,507

Pulverized Fuel Equipment Sales

Orders for 8 pulverizers with a total capacity of 91,500 lb. per hr. were placed in November

	STORAGE SYSTEM						
	Pulverizers				Water-tube Boilers		
	Total Number	No. for new boilers, furnaces and kilns	No. for existing boilers	Total capacity lb. coal per hour for contract	Number	Total sq. ft. steam generating surface	Total lb. steam per hour equivalent
November, 1932	..	..	..	....	..	....	......
November, 1931	..	..	..	....	..	....	......
January to November (inclusive, 1932)	..	..	..	....	..	....	......
Equivalent period, 1931	8	7	1	250,000	4	126,471	1,797,000
Total, 1931	8	7	1	250,000	4	126,471	1,797,000
	DIRECT FIRED OR UNIT SYSTEM						
	Pulverizers				Water-tube Boilers		
November, 1932	8	8	..	91,500	4	151,200	907,200
November, 1931	5	3	2	17,850	5	22,590	163,600
January to November (inclusive, 1932)	73	48	25	392,388	64	463,194	3,536,260
Equivalent period, 1931	70	51	19	448,460	56	409,477	4,433,595
Total, 1931	72	52	20	450,960	58	417,327	4,455,585
					Fire-tube Boilers		
November, 1932	..	..	..	......	..	......	....
November, 1931	..	..	..	......	..	......	....
January to November (inclusive, 1932)	13	2	11	13,300	13	20,310	114,650
Equivalent period, 1931	34	11	23	38,800	36	58,261	340,100
Total, 1931	35	11	24	39,300	37	59,761	347,100

ADVERTISERS

in this issue